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The Glass Industry—1960

A REVIEW

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Glassmaking in the United States has become a $2-billion business with an annual production of more than 8 million tons of glass products. One of the first industries in North America, it gives every indication of continued, steady growth.

DURING 1960 the glass manufacturing industry experienced generally a satisfactory and successful year in spite of the fact that the inroads of foreign competition became increasingly serious. For some years, this competition has been especially noticeable in the tableware and art glass fields, where skilled foreign artisans have produced by hand many beautiful crystalware products. More recently competition from abroad has been encountered in flat glass, especially window glass, and in the electronics industry, particularly radio and television and allied products.

When all the figures are in, flat glass production, including window glass and plate glass, is expected to be about 18 per cent below that of 1959, the lower production clearly reflecting the influence of foreign importation. U. S. tariff reports indicate that for the first six months of 1960 window glass imports were equal to 32.3 per cent of domestic production, while in the second quarter they equaled 38 per cent of domestic production. These figures may be contrasted with those of previous years: 1959, 31.3 per cent; 1958, 28.5 per cent; and 1957, 17.3 per cent. The competition from imports will undoubtedly continue to affect the flat glass field, and unless some relief is obtained through tariff regulations, successful competition will be met only by increased mechanization and continued lowering of production costs.

Shipments of glass containers continued at a very high level during 1960, with production probably equaling that of 1959. This branch of the industry now does an annual business in excess of $1 billion, with a production of about 23 billion units.

Very impressive growth records were also reported in the fields of fiber glass and electronics. The sales volume of the former will be in excess of $300 million, while that of the latter will be approximately $10 billion.

The year 1960 was especially productive in the planning, construction, and operation of a number of new facilities, as well as in the expansion and modernization of older ones.

1. PITTSBURGH PLATE GLASS COMPANY: a new fiber glass yarn plant at Shelby, North Carolina.
2. OWENS-ILLINOIS GLASS COMPANY: to build a multi-furnace glass container plant in Brockport, New York. The company has also started construction of a new container plant in New Orleans, Louisiana.
3. CORNING GLASS WORKS: (*a*) to construct a plant at Raleigh, North Carolina, which will be devoted entirely to the manufacture of electronic components. (*b*) Has also announced plans for a new research and engineering center to be located near the company's

headquarters in Corning, New York. The new center, the Eugene C. Sullivan Science Park, will honor Dr. Eugene C. Sullivan, founder of the company's research laboratories. (*c*) Greencastle, Pennsylvania, is the site chosen for a new Corning plant which will handle assembling and warehousing of its houseware products and serve as a distribution center for products sold by Corning's Consumer Products Division. (*d*) The melting tank at the company's new Martinsburg, West Virginia, plant was lighted early this year. The plant is devoted to the manufacture of Pyroceram cooking utensils.

4. GLENSHAW GLASS COMPANY, INC.: plans to have a new container plant at Orangeburg, New York.
5. CHATTANOOGA GLASS CO., subsidiary of Dorsey Corp., has begun installing the first electric glass bottle furnace in U.S.
6. THATCHER GLASS MANUFACTURING CO. opened a $4-million plant with a capacity of more than 100 tons of glass a day at Tampa, Fla.
7. LIBBEY-OWENS-FORD GLASS COMPANY: has moved into its new 15-story, glass-clad executive building in Toledo, Ohio.
8. GUSTIN-BACON MANUFACTURING COMPANY: Kansas City, completed a multi-million-dollar expansion of production facilities in Kansas City, Kans., which will more than triple the company's output of fiber glass building insulation for residential construction.
9. PHOENIX GLASS COMPANY, Monaca, Penn.: relocated and modernized certain production facilities, which will improve scheduling of glassware for decorating and delivery.
10. OWENS-CORNING FIBERGLAS CORPORATION: has a new textile products plant in Aiken, South Carolina.
11. BROCKWAY GLASS, INC.: started construction on a new plant at Minneapolis, Minnesota.
12. MODIGLASS FIBERS, INC. (bought by Reichold Chemicals): is making extensive improvements and enlarging their Bremen, Ohio, plant.
13. METAL & THERMIT CORPORATION: expended its mineral mining operations at Hanover County, Va., to develop substantial quantities of aplite. The mineral is used by the glass industry as a source of alumina in the production of colored and flint container and window glasses.
14. OWENS-ILLINOIS GLASS COMPANY: doubled the capacity of its Valencia, Venezuela, glass container plant. Floor space was expanded by 100,000 sq. ft. to accomodate an additional glass-melting furnace and three automatic bottle-making machines.
15. CARBORUNDUM COMPANY and Harbison-Walker Refractories Company: tripled the plant capacity of their joint operations in Falconer, N. Y. (See THE GLASS INDUSTRY, page 18, January, 1960.)
16. FALCONER PLATE GLASS CORPORATION: completed construction of their new 20,742 sq. ft. office and warehouse building.
17. JOHNS-MANVILLE FIBER GLASS: doubled the size of its Corona, California, plant.
18. HENRY F. TEICHMANN, INC.: expanded their engineering department and company offices in Washington County, Pa., by 1800 sq. ft.
19. FISCHER & PORTER COMPANY: leased a two-story plant from Davisville Hosiery Mill, Inc., Warminster Township, Pa., to expand production facilities of industrial glassware, laboratory glassware, digital data acquisition and water and waste treatment, and process control.
20. OWENS-ILLINOIS GLASS COMPANY: purchased a minority interest in Actien-Gesellschaft der Gerresheimer Glashuttenwerke, vorm. Ferd. Heye, Dusseldorf, Germany. The 25 per cent interest in Gerresheimer Glass was exchanged for stock and cash.
21. JOHNS-MANVILLE FIBER GLASS: expanded its Carpenter Road plant in Defiance, Ohio, by 126,000 sq. ft.
22. SELAS CORPORATION: licensed Societe Exploitation de Produits Industriels, (Paris) to manufacture and sell Selas heat processing equipment to glass, ceramics, metals, and allied industries in France.
23. HAZEL-ATLAS GLASS DIVISION: constructed a $1.5-million research and development laboratory at Plainfield, Ill., for research on glass compositions, melting, new methods of forming and treating glass, and developing new glass container products.
24. OWENS-ILLINOIS GLASS COMPANY: became a major stockholder in Compagnie Internationale de Gobelterie Inebrechable S.A., Soignies, Belgium. O-I now owns 97 per cent of the company's stock.
25. KNOX GLASS, INCORPORATED: plans construction of multi-million-dollar plant near Atlanta, Ga., to manufacture glass containers.
26. METRO GLASS COMPANY, INC.: became Metro Glass Division, National Dairy Products Corporation.
27. GLENSHAW GLASS COMPANY, INC.: to construct a 150,000 sq. ft., one-story glass container manufacturing plant at Orangeburg, N. Y.
28. PITTSBURGH PLATE GLASS INTERNATIONAL: and Algemene Kunstzijde Unie N.V. agreed to enter a study on the establishment of a continuous fiber glass yarn plant in Western Europe, probably Holland.
29. BALL BROTHERS COMPANY, INC.: purchased Atlantic Zinc Works, Inc., and its subsidiary, Rolled Plate Metal Company, Brooklyn, N. Y.
30. OWENS-ILLINOIS GLASS COMPANY: scheduled a multi-furnace glass container plant to be completed in 1961 at Brockport, N. Y. It will occupy approximately 300,000 sq. ft. on a 70-acre site.
31. ARMSTRONG CORK COMPANY: rebuilt and enlarged one of five glass melting furnaces at their Millville, N. J., glass container plant to increase production capacity by 35 per cent.
32. DRAKENFELD & COMPANY: expanded its factory and research center in Washington, Pa.
33. FERRO CORPORATION: purchased the Vitro Manufacturing Company division of Vitro Corporation of America for approximately $500 million.
34. FOOD MACHINERY AND CHEMICAL CORPORATION: completed its Chemical Research and Development Center at Princeton, N. J.
35. GLASCOTE PRODUCTS, INC.: announced broad expansion plans designed to double production facilities and enable the company to provide larger units for the chemical reactor field.
36. WHEATON GLASS COMPANY: purchased Owens-Illinois Glass Company's glass container plant in Terre Haute, Ind.
37. OWENS-ILLINOIS GLASS COMPANY: purchased a minority interest in Companhia Industrial Sao Paulo E Rio, a leading glass container company in Brazil.
38. REICHHOLD CHEMICALS, INC.: negotiated with Nicolet Industries, Inc., for the purchase of the Modiglass Corporation.
39. FOOD MACHINERY & CHEMICAL CORPORATION: expanding production of soda ash output at its Green River, Wyoming, plant. Expansion will be completed by early 1962.
40. FORD MOTOR COMPANY (GLASS DIVISION): gave Toledo Engineering Company, Inc., a multi-million-dollar contract for the complete designing and erection of two glass melting furnaces and auxiliary equip-

ment at the Ford glass plant in Nashville, Tenn.

41. SHATTERPROOF GLASS CORPORATION: began constructing a modern two-story administration building adjacent to its Detroit manufacturing plant.
42. AMERICAN CAN COMPANY: entered the glass container manufacturing field with the creation of its majority-owned subsidiary, The American-Wheaton Glass Corporation. Wheaton Glass Company, Millville, N. J., manufacturers of pharmaceutical and cosmetic glass containers, are minority interest holders in the new company. The first plants will be in Terre Haute, Ind., and Minneapolis, Minn.
43. MOLDED FIBER GLASS BODY COMPANY: doubled its polyester resin production to a total of 10 million pounds.
44. ARMSTRONG CORK COMPANY: increased its glass container production capacity by 50 per cent at its Dunkirk, Ind., plant with the installation of a new end port type glass melting furnace.
45. BINSWANGER GLASS COMPANY: formally opened its enlarged and remodeled mirror manufacturing facilities at Grenada, Miss.
46. OWENS-ILLINOIS GLASS COMPANY: purchased an 88-acre industrial site in Los Angeles for future use as the location of a manufacturing plant.
47. BALL BROTHERS, INC.: began construction on a glass container manufacturing plant at Mundelein, Ill.
48. OWENS-CORNING FIBERGLAS: opened its new technical research center at Granville, O. At the opening it was announced that the company will increase its capital expenditures by 10 per cent to $44 million. (See THE GLASS INDUSTRY, page 635, November, 1960.) The company also announced that it had developed a fiber glass for the Air Force that had a 50 per cent greater rigidity with no sacrifice in strength.
49. KAISER REFRACTORIES & CHEMICAL DIVISION: began construction on a new Technical Center at Mexico, Mo.
50. CORNING GLASS WORKS: announced the building of a new plant for the manufacture of electronic components at Raleigh, N. C. The company also announced plans for the construction of the Eugene C. Sullivan Science Park, a 400-acre research and engineering center near Corning, N. Y. The group of buildings will be erected during the next five years.
51. FELDSPAR CORPORATION: completing construction on its Middletown, Conn., plant.
52. B. F. DRAKENFELD & COMPANY, INC.: broke ground for a 24,400 sq. ft. addition to their Plant B in Washington, Pa.
53. BINSWANGER GLASS COMPANY: completing work on its Port Arthur, Texas, facilities at the end of the year. Expansion of the Meridian, Miss., operations were completed in November.
54. AMERICAN-ST. GOBAIN: began construction on its $40-million plate glass plant near Kingsport, Tenn.
55. ARMSTRONG CORK COMPANY: began a major expansion program in late November at its glass container plant at Millville, N. J.
56. HARBISON-CARBORUNDUM CORPORATION: added a new electric arc melting furnace to the research facilities at Falconer, N. Y.
57. OWENS-ILLINOIS GLASS COMPANY: began producing face plates for 19- and 23-inch television picture tube bulbs at their Muncie, Inc., plant.
58. REICHHOLD CHEMICALS: increased its ownership of Modiglass Fibers, Inc., to approximately 95 per cent by exchanging common stock shares with Modiglass.
59. MOLDED FIBER GLASS BODY COMPANY, Ashtabula, O.: and the Molded Fiber Glass Tray Company, Linesville, Pa., announced plans to merge effective January 1, 1961.
60. FERRO CORPORATION, Nashville, Tenn.: announced plans for the construction of a $2.5-million industrial plant in Huntington Beach, Calif.

Other new glass container plants include Anchor Hocking, San Leandro, California; Ball Brothers Company, Ashville, North Carolina; Metro Glass Company, Cartaret, New Jersey; and Thatcher Glass Manufacturing Company, Tampa, Florida.

I. FLAT GLASS

The production of both window glass and plate glass for the first three quarters of 1960 is given in Table I. Estimates of the total production for 1960 indicate there has been (approximately) an 18 per cent decrease in production—evidence of the effect of increased imports. In 1960 about 6½ million automobiles were manufactured, an appreciable increase over 1959, and, therefore, a marked increase in demand for flat glass would have been expected.

There is definite hope for increased building activity in 1961, and the demand for glass building facing material, such as clad-wall construction and double glazing, should provide increased demands for flat glass. Private home building in 1961 will increase 4 per cent over last year rate, the Commerce Department has predicted. Work will be started on 1,300,000 dwelling units in 1961, compared with an indicated 1,250,000 for all 1960. Department officials have stated that this forecast assumes a strong recovery in the latter half of 1961.

Brightness Control Glass

A new gray sheet glass for building areas which require brightness control has been developed by Pittsburgh Plate Glass Company. Called "Graylite," it will substantially reduce the need for supplementary light control measures from blinds, hoods, louvres, or other shading devices. It is recommended for glazing elevations facing east, southeast, west, southwest, and points between, especially those which are subject to exposure by direct sunlight. It is also advantageous for use in ribbon windows and ventilator units in conjunction with light-directing glass block installations.

Distortion-Free Glass

Advances in manufacturing techniques in drawing molten glass have made possible an improved sheet glass that is considered superior to any sheet glass previously manufactured in the United States, according to standard distortion measuring devices.

Known as "Premium Pennvernon," the glass is free from distortion and is manufactured on the Pennvernon machine. The process employs a straight vertical draw by which molten glass is formed into sheets without being touched by any mechanical device to mar its surface.

TABLE I

PRODUCTION AND SHIPMENTS OF FLAT GLASS*

Sheet (window) glass (not rolled) including colored:	1,000 boxes of 50 sq. ft. each single strength and equivalent		
	PRODUCTION[1]	SHIPMENTS	
	(Quantity)	(Quantity)	Value ($1,000)
First Quarter	6,329	4,985	25,857
Second Quarter	4,850	4,550	22,801
Third Quarter	5,141	5,326	26,912
Total	16,320	14,861	75,570
Estimated by author 12 months 1960	21,700	19,800	101,000
Plate and other flat glass[2]:			
	1,000 square feet		
First Quarter	190,020	127,206	49,729
Second Quarter	166,981	109,522	40,692
Third Quarter	153,667	102,624	40,143
Total	510,668	339,352	130,564
Estimated by author 12 months 1960	680,000	452,500	174,000

*Source: "Current Industrial Reports"—U. S. Department of Commerce.

[1]Production figures include the quantities shipped as well as the quantities incorporated into other products manufactured by establishments producing glass.

[2]Includes data for wire and rolled glass, translucent, opaqued, roughed, or otherwise impressed. Excludes information for block and tile.

The product is expected to find a high degree of acceptance among architects, sash manufacturers, automobile manufacturers, and manufacturers of flat glass specialty products. Noticeably more attractive in a building installation than other sheet glass, Premium Pennvernon is the most nearly optically perfect glass now available for architectural uses—short of the ultimate perfection obtained only in ground and polished plate glass.

Flat Glass in the Aircraft Industry

Some of the more significant and practical developments in the use of flat glass have been made in the aircraft field. "Nesa," an electrically-conductive glass, has been developed for minimizing icing and fogging conditions on airplane windshields. "Flexseal," which is made of special safety laminated aircraft glass designed to resist the friction of supersonic flight, is used in windshields of jet-propelled aircraft today. It is comprised of two or more pieces of regular semi-tempered or tempered polished plate glass and plastic interlayer in either single or multi-glazed units. In Flexseal, the plastic sandwiched between the glass extends beyond the glass edges so that the plastic can be secured to the aircraft frame. Nesa also is used in making Flexseal units for aircraft.

"Multiplate," a laminated glass of several pieces of polished plate glass and plastic interlayers, has been developed for protective purposes in aircraft armor.

The following are examples of the numerous aircraft in which glass components have been applied:

Convair Model F-102 ..... All-weather high altitude plane utilizing sizeable applications of Nesa-Flexseal units in vision areas.

Convair Model 880 ..... Commercial transport (jet liner) incorporating Nesa-Flexseal windshields. Can accommodate maximum 108 passengers; cruising speed 600 MPH with a 3,000-mile range. Altitude 30-40,000 feet.

Boeing Model B-52 ..... High altitude long range bomber having 24 windshields incorporating Nesa and Flexseal parts. Performance: maximum speed in excess of 650 MPH with an altitude of 50,000 feet.

Boeing Model KC-135 ..... Refueling tanker for B-52, has 13 Nesa-Flexseal windows.

Boeing Model 707 ..... Commercial airliner with a 600 MPH performance, with range of 4,000 miles. Maximum capacity of 147; 40,000 feet normal flying altitude.

Lockheed Model C-130 ..... "Hercules," medium assault transport having 9 Nesa-Flexseal windshields and 14 Flexseal non-Nesa windshields; has 4,300 cubic feet capacity for standard accommodation of 92 soldiers (paratroopers).

Douglas Model DC-8 ..... Commercial liner with 5 Nesa-Flexseal windshields and 3 Flexseal non-Nesa windows; passengers, 132; 600 MPH with 30-40,000 feet altitude and a maximum range of 4,800 miles.

Republic Model F-84 ..... Fighter aircraft (Tactical reconnaissance) with Nesa-coated multiple windshield. Maximum speed in excess of 650 MPH with a ceiling over 45,000 feet, combat radius of over 1,000 miles. Known as "Thunderstreak."

Use of Radioactive Tracers

A research reactor has been largely instrumental in successfully conducting radioactive tracer experiments designed to study flow paths and flow rates of various sizes of sand in a sand grading system of the Cumberland, Maryland, plate glass plant of Pittsburgh Plate Glass Company.

In preparing the tracer, common sand was irradiated in a research reactor to produce the radioactive sand, which was immediately transported to the plant. According to radiation services officials of the company's glass division research center, sand in the plant is graded for the purposes of grinding the glass surface prior to polishing.

Two recent experiments have contributed substantial useful knowledge to the operational procedures of the grader system, and the high sensitivity of the radioactive tracer technique surpasses other tracer techniques evaluated. The short half-life and eventual great dilution of the tracer sand at the plant site eliminates any radiation hazard.

New Windshield Adhesive

A new adhesive applied to glass and rubber weatherstrip on automobile windshield and backlight, which creates a permanent bond, similar to vulcanizing in rubber, has been developed. Called "Duribbon," it is said to be the first to provide a permanent seal for the heavy, complex glazing of modern automobiles. It is capable of lasting the lifetime of the car. Ten years of research and development were required to perfect a material of sufficient strength to maintain a permanent bond that could withstand movement of the heavy glass on the automobile body flange.

Independent tests have shown that the material possesses unique characteristics in its field. It is the only known sealant of its type that will withstand atmospheric conditions in any part of the world. Duribbon will be provided mainly for automobile manufacturers and auto glass replacement shops. One major manufacturer has field tested it on the assembly line with great success.

New Lightweight Insulation Glass

In the realm of new products, Libbey-Owens-Ford Glass Company has made a special effort to promote its lightweight GlasSeal Thermopane as an effective insulation element for homes. This unit fits most wood or metal sash with a minmum change in balances and weights on conventional double-hung and other types of window sash. It is made with single strength "A" quality window glass in a large number of standard sizes on automatic machinery.

Glass Roof for Cars

All-weather convertibles—motor cars with large roof areas of glass providing safety, comfort, and beauty combined with unexcelled vision—are now distinctly within the realm of possibility. It has been pointed out that the first steps toward all-glass tops have been in some models with their "twin-wrap" windshields curving into the roof area, combined with exceptionally high rear windows.

Current research in glass gives promise of new and startling products. Some of these are already being adopted in reply to the public's desire for ever-increasing glass areas, for example, the growth in windshield areas from 3.7 to over 11.0 square feet in the last 20 years.

Variable Transmission Glass

Glass research has already found good answers to the heat and glare problems in the all-glass roof, but the ultimate objective for this purpose is the development of a variable transmission glass. This is a type of glass whose ability to transmit light and radiant heat would be adjusted automatically. Its development is an active glass research project and seems technically possible.

Technicans have also developed colored laminated and coated tempered glasses. These reflect or absorb up to 83 per cent of the sun's heat and are being used on current models of cars.

II. CONTAINER GLASS

In 1960, for the sixth successive year, U. S. production of new glass containers reached a very high level, estimated to be 161 to 165 million gross containers, or about 23 billion units. Nearly 6.6 million tons of glass were produced. Both shipments and production of new glass containers for the first eight months of 1960 and 1959 are compared in Table II. The estimated shipments of glass containers for 1960 were slightly lower than production figures, which suggests some accumulation of stock. This accumulation may affect production in the first part of 1961.

Trends and New Developments

In the realm of manufacturing advances, the important factors are: faster production speeds, lightweighting, increased strength, and bottle coatings. The production speed of modern glass-forming machinery is such that bottles can now be made at a rate of some 250 per minute as compared with the maximum rate of 30-40 a minute

20 years ago. Some manufacturers have set a goal of doubling the present production speeds during the next decade and have an eventual goal of making 700 or more units per minute.

The glass manufacturer is extremely conscious of the fact that present practices utilize only about 1 per cent of the measurable laboratory strength of glass. Ordinary glass fibers show tensile strength of 1 million pounds per square inch, much stronger than the strongest steels. Unfortunately, glass is susceptible to stress concentrations, or, in the terms of the engineer, "notch sensitivity." Glass is weakened by pits, scratches, chips, and abrasions, which act as sites for concentration of the stresses that tend to cause breakage. The industry goal is to raise the utilization of the inherent strength of glass from the present 1 per cent to approximately 10 per cent.

Small No-Deposit Bottle for Beer

Manufacturers of glass bottles are staging a major campaign to win back the beer packaging markets they have lost to metal cans in recent years. Their weapon is a lightweight no-deposit bottle that can be thrown away after use instead of being returned to the store. The manufacturers are backing up the new bottle with a large-scale advertising program in which many brewers are participating.†

The 12-ounce-size bottle is slightly more than 5½ inches high and weighs 5¾ ounces. This compares with 7½ inches and 7 ounces for previous versions of the one-way bottle and 9½ inches and 10½ ounces for the high-neck returnable bottle.

The new bottles have a stubby design that gives them a can-like appearance. The more compact design means the bottles take up less space in breweries, store shelves, and home refrigerators.

At least forty-five brewers across the country are now using the new type of beer bottle.

Bottle Coatings

Among the various means of achieving bottle coatings are:

1. Fire polishing to heal flaws
2. Treatment with hydrofluoric acid polishing solution to round off the defects.
3. The application of coatings to the glass surface to minimize damage.

Procedures (1) and (2) are too costly and too complicated to be considered commercially feasible at this time; hence, major interest has been, and will continue to be, directed to bottle coatings.

Among the materials which have been used as coatings are sulfur, metallic oxides, waxes, resins, silicones, and plastics. Unfortunately, no universally suitable coating has so far been developed, for each one now in use fails to fulfill one or more of the basic features required.

Sulfur, for example, produces an objectionable white or grayish bloom on the glass. Metallic oxides are somewhat difficult to apply and leave an undesirable sheen.

TABLE II

GLASS CONTAINERS: SHIPMENTS AND PRODUCTION*

(Figures are quantities expressed in thousands of gross)

ITEM	SHIPMENTS Cumulative January-August		PRODUCTION Cumulative January-August		TOTAL** Estimated Shipments	TOTAL** Estimated Production
	1960	1959	1960	1959	1960	1960
ALL TYPES, TOTAL	106,075	107,706	110,463	105,057	159,113	165,695
Direct exports	1,507	1,642	xxx	xxx		
Domestic	104,568	106,064	xxx	xxx		
DOMESTIC, BY TYPE						
Narrow neck, total	67,339	67,215	70,759	66,476	104,009	106,139
Food	11,237	11,590				
Medicinal and Health	10,693	11,342				
Household and industrial	7,624	8,075	38,589	38,141		
Toiletries and cosmetics	7,271	7,278				
Beverage, returnable	7,437	7,425	8,288	7,403		
Beverage, nonreturnable	1,195	1,039	1,304	1,042		
Beer, returnable	2,608	2,560	2,874	2,533		
Beer, nonreturnable	9,793	7,120	9,839	6,914		
Liquor	6,202	7,448	6,476	7,329		
Wine	3,279	3,338	3,389	3,114		
Wide mouth, total	37,229	38,849	39,704	38,581	50,844	58,274
Food[1]	29,329	30,735				
Medicinal and health	3,193	3,199				
Household and industrial	1,327	1,341	38,520	37,250		
Toiletries and cosmetics	2,255	2,275				
Dairy products	1,125	1,299	1,184	1,311		

[1] Including fruit jars, jelly glasses and packers' tumblers
* "Current Industrial Reports," U. S. Department of Commerce
** Estimated by the author

† See THE GLASS PACKER, December, 1960, page 23.

Waxes are water soluble and hence not permanent, while silicones present labeling difficulties and problems in proper application.

Another aspect of bottle coating which is at present being given considerable attention is the development of procedures for application of ultra-violet absorbing compounds to the glass surface so as to screen out the sun's actinic, or chemically active, rays. The short wave lengths of the visible spectrum and the near ultra-violet are considered the source of the chemically active radiation responsible for color, odor, and flavor changes—as well as loss of potency of drugs.

Of the commercially available glass colors on the market today, only amber and a special formula green offer the protection required for light sensitive products. The lack of aesthetic appeal of amber and the somewhat limited availability of the special green do not allow their use for many products.

Future developments in application of the ultra-violet absorbing materials would greatly aid packers of light-sensitive products. Among the problems to be solved before such coatings are commercially feasible are (1) cost of application, (2) curing procedures, and (3) reduction in the color imparted to the containers. These are not considered to be insurmountable barriers, however.

New Equipment

New equipment announced by Emhart Manufacturing Company includes batch chargers, forehearths, and feeders. The batch chargers are intended to increase melting rates and melting capacities of furnaces. The new forehearth was designed to increase the cooling capacity necessary because of the requirement for more glass. The new feeder has many improvements, as well as being capable of handling additional glass.

Practically all the machinery used for glass forming—including feeders, forming machines, conveyors, and stackers—is now equipped with automatic lubrication. This type of lubricating equipment has been installed to increase the life of the equipment between major overhauls.

The most important advance during 1960 has been the increased use of double gob, not only in the total percentage of ware produced by double gob, which is nearing 50 per cent, but also in an expansion in the range of size and weight of ware that can be produced by the double-gob process.

The maximum amount of glass required for a 6-section I.S. Machine previously was of the order of 40 U.S. tons per day. The amount required now is nearing 50 U.S. tons per day. This means that, with modification of existing equipment, production can be increased about 25 per cent. To keep abreast of the demand of the forming machine, it has been necessary to modify feeding, annealing, and handling for the increase in productivity.

The demand continues to grow for automatic handling and inspection equipment. Improvements have been made which allow for handling of a larger variety of glassware. Because of longer furnace campaigns it has been necessary to improve feeder refractories for longer life. The use of Hartford-Empire Unit Melters continues to grow. There are now 85 throughout the world, either in operation or being constructed.

Thermal Shock Resistance

Glass is designed to withstand a thermal differential of approximately 70°F. Any attempt to fill beyond this limit sets up sufficient stresses to cause failure.

Since many products are filled hot, it is essential that this differential be considered, especially when containers have been exposed to cold temperature during transit or storage. Preheaters—either warm sprays, steam injection, or radiant heat—have proven to be very helpful in reducing the incidence of thermal shock breakage with hot fill products.

Desire for Still Lighter Containers

Right now the glass container industry is in the midst of a new round of lightweighting. With improved designs and better molding techniques, the resourceful glass makers are finding ways to take off still more avoirdupois in places where it will help, and not hurt, the function of the container. So important in this weight reduction is the design of the container—the distribution of glass and the physical characteristics of the glass—that they prefer to call it "rightweighting." Between 1930 and 1956 the average glass container shed a third of its weight. In the last few years it has slimmed down another 20 per cent.

With freight rates going up on what seems to be an endless escalator, lightweight packaging materials, with improved properties and functions, are steadily improving their position on shipping cost alone. But the glass container, the long-time heavy-weight champion, does not intend to take this challenge lying down.

It must be emphasized that lightweighting is practical only when accompanied with strength that gives sufficient resistance to impact, to internal and external pressure forces, and to wide temperature differences. Such "rightweighting" can be accomplished through exact chemical and physical control of the raw material and the finished glass through scientific shaping of the container to control impact forces and through rigidly regulated furnace temperatures, higher-speed handling of molten glass, more accurate control of time and temperature factors in the forming process, better control of mold cooling, lubrication and design, and improved annealing or tempering, coupled with improved methods of handling hot ware. The ideal glass container would be one as light in weight as an electric light bulb and as strong as steel. Toward this goal the glass container industry constantly drives.

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Architectural Art In An Entrance

The new Corning Glass Works Building on Fifth Avenue in New York City.

The gleaming glass exterior, extending 28 stories high, has been repeatedly described as one of the few new really interesting New York skyscrapers.

The building is clad in 4½ acres of green heat-absorbing glass held in slim, dark anodized aluminum frames so as not to detract from the overall gleaming glass effect.

The architectural firm of Harrison & Abramovitz & Abbe devised a unique application of a 60-year-old glass product to make the entrance to the exclusive Steuben Shop a sparkling eye catcher and an instrument to complement effectively the dark building with a permanent, attention-compelling white entrance that is the acme of modern decor.

White non-solarizing Carrara glass, the only known material that will retain its whiteness forever, was chosen in two finishes, one ground and polished to mirror-like perfection and the other a soft suede for contrast.

A prism design snowflake pattern, 48 inches in diameter, was laminated to the center expanse of white Carrara.

Two 16-foot-high panels on either side are the largest lites of the opaque structural glass used to date in an exterior application.

The unique white Carrara panels surround a stainless steel door frame having a tempered glass door and sidelites.

GLASS in the World of TOMORROW

by Elmer A. Lundberg,

Director of Architectural Services, Pittsburgh Plate Glass Co.

Mr. Lundberg has just been elected President of the Producers' Council, an affiliate of the American Institute of Architects. We accordingly asked him to express his ideas on the future of glass in the architectural and automotive fields.

ED.

THE recently completed Pittsburgh Hilton Hotel in Pittsburgh's Gateway Center is a striking example of progress in glass. Of the several types of glass used on this architectural showplace, not one single glass was available just five years ago.

This is only one of many architectural showplaces in glass and is, I believe, but a minor indication of the tremendous future in store for glass.

Glass in the "World of Tomorrow" may be several

things. First, it may be an entirely different kind of product performing different functions from what are common and accepted now. Second, it may be the same product with different treatment of fabrication to give an entirely new end-result. Third, the form of tomorrow's glass will depend largely on what we accept and want glass to do in our every-day living.

To picture the future of glass, I believe the expression of Dr. J. Robert Oppenheimer, Director of the Institute of Advanced Science at Princeton, used in addressing the architects at their 1960 Annual Convention, would be most appropriate. He commented that the architects should look at the urban renewal and planning of communities with "a wide open lens." This same statement can be applied to our approach to glass. In fact, we have almost an unlimited perspective.

Houses

In the interior of a house we have a floor, walls, windows, doors and a ceiling—all of which can now be made of glass. Perhaps the only innovations would be that the walls could be variable and change color (become transparent or opaque) or become hot and cold to add to our comfort. I am sure you are thinking it is going to be a rather noisy affair with all these reflecting surfaces, but a wall could be of a fiber glass fabric and these same fibers could be woven into a carpet.

The ceiling of our house of the future may have a cellular glass that breathes and also acts as the light source. Thinking in terms of heating and air conditioning, this could be a dropped ceiling or, better described, a ceiling lowered from the floor structure above, which would act as a plenum for controlled air distribution and would also soften the light source.

The conventional window area of the house of the future could well include double-glazed sliding doors on at least two complete elevations, with these windows again having the ability to be made opaque—colorful, or clear, or tinted.

This certainly seems possible with further advancement of one of our glass research developments known as variable transmission glass.

We already are aware of glass roofs on homes to collect heat and store it for later reuse. We are familiar with glass plumbing pipes and fiber glass ducts.

Buildings

Again in buildings as in houses, we have walls, ceilings, floors and windows, all of which could be of glass, but more importantly, there is a study being carried on at Pennsylvania State College under a grant from Pittsburgh Plate Glass Company with regard to the use of a double outside wall. In other words, a glass-clad building within a glass enclosed building.

This program is to study its practicality with respect to using a perimeter glass wall enclosed area for heating and cooling and also for containing the service of plumbing and wiring. It has many interesting features.

In buildings of the future, I can see walls of glass with no visible metal support—probably accomplished by new techniques in welding glass or bending its edges severely without weakening the structure. As a result, the glass no doubt would be thicker and could even be in larger lites with perhaps transparent, welded joints. All of this, I am sure, to a practical engineer or construction man sounds impossible, but it is still not as blue sky as the completely glass-domed cities we sometimes see written up in some of our comics and magazines.

It would not seem too unreal to have a steel structure first erected and then sheets of glass welded to its outside. This welding technique naturally overlooks many of the problems we share today, but with more reesarch, and a little luck, I would not be surprised if it did happen.

Automobiles

The entire roof of our future cars could be made of glass. I visualize this roof as combining the technique of welding with that of the variable transmission glass principle, so that the driver could control with a knob the degree of shade or opacity he wants in the roof and even the amount of heat or cold. Perhaps this same effect could be accomplished by having the roof as two pieces of glass (laminated) with the laminate performing the necessary comfort functions.

I can visualize even all-glass bodies for our future cars, thinking in terms more of a fiber glass combination rather than conventional glass as we regard it now.

Even highways could be made of glass, and what a future if they were lighted from under the ground or edge-lighted for night driving. Color lighting could be incorporated so your route could be by color, rather than by number as we now have. These glass highways would never require snow removal because the light source could also be a heat source to keep it free from ice and snow.

We already have been reading about cars automatically driving themselves on super highways, so why not go all out and enjoy these comforts?

Stores

Naurally, our stores are going in for more glass, and it is not too hard to believe that our future metropolitan streets will be completely covered with glass in an arch form so that we have protected sidewalks and malls that also will be heated and air conditioned.

Innovations

I think we shall have glass which we can see through, and also breathe through, although at the moment I can't justify its existence unless as a ceiling material in a more opal state.

We probably can expect swimming pools of glass, with the entire pool lighted at night rather than by port lights.

(*Continued on page* 103)

Conditions of Glass Formation Among Simple Compounds* IN FOUR PARTS: Part III (*concluded*)

by W. A. Weyl and E. C. Marboe, College of Mineral Industries, The Pennsylvania University, University Park, Pennsylvania, U.S.A.

1. Defective Crystals

In contrast to those ceramists who work in the field of dielectrics such as titanates, glass technologists had no need to study the theory of defect structures because they rarely deal with crystalline materials.

Tin oxide, as used for surface coating of glasses and as suggested as an electrode material for electrical booster melting, is an example of an oxide which becomes electronically conducting because it develops lattice vacancies. It has been found possible to control the concentration of defects in such an oxide and to increase or decrease its conductivity by introducing "foreign atoms" into its structure.

A great deal of the present interest in solid state physics is centered around crystals which contain a controlled concentration of defects and foreign atoms. Physicists approach this subject on the basis of the band theory. During the last decade we have developed a chemical or crystal-chemical approach to semiconductors and defective structures[37, 38].

In the past, glass technologists have had no reason to become familiar with our approach to defect structures. This situation, however, has now changed. We found that a relation exists between the electronic conductivity of an oxide, its melting behavior, its nucleation rate, and therefore its tendency to form a glass. This should be of interest to those who are engaged in research on catalysts which control nucleation, e.g., TiO_2, or in the development of glasses on the basis of oxides which because they are semiconductors (Bi_2O_3, TiO_2, V_2O_5) do not form glasses by themselves.

A rutile crystal when partly reduced, either by heating it to high temperatures or by exposing it to a reducing atmosphere at lower temperatures, changes into a semiconductor of the n-type. The crystal which has been an insulator when perfect has now become an electronic conductor because the partly reduced, non-stoichiometeric crystal has electrons in its conductivity band. According to our atomistic description, the crystal contains electrons which are quantized with respect to a group of Ti^{4+} cores rather than to one or two cores. We prefer to describe such a crystal as not containing defined Ti^{3+} or Ti^{2+} ions, but to give it a formula

$$Ti^{4+}\,O_2^{2-} \xrightarrow{-x\ 0} Ti^{4+}\,(e^-)_{2x}\,O^{2-}{}_{2-x}\,(A.V.)_x$$

which indicates the presence of 2x electrons in the conductivity band and x anion vacancies (A.V.) per mole TiO_2. The appearance of electrons in a crystal structure which are available for carrying an electric current is of primary interest in semiconductor research. As far as glass formation is concerned we are primarily interested in the formation of vacancies in the crystal because the latter are the centers of an asymmetry which affects the binding forces.

The concept that vacancies in a crystal enhance mobility, in particular, diffusion and recrystallization or sintering, is well supported by experiments. It is also known that the number of vacancies in a crystal can be increased or decreased by introducing into a crystal the proper "impurities" or "foreign atoms".

P. A. Marshall, D. P. Enright, and W. A. Weyl[39] found that by selecting the proper additions, the sintering rate of ZnO at a given temperature can be accelerated as well as slowed down. Additions which change the rate of sintering also affect the electronic conductivity of a semiconductor such as ZnO or TiO_2. This relation between the effect which an impurity exerts upon the electronic conductivity and the lattice vacancies of a semiconducting oxide enables us to use the electronic conductivity as a tool for examining the structural changes which occur in a crystal if foreign atoms are introduced. G. H. Johnson and W. A. Weyl[40] carried out such an investigation using rutile as an example.

A defective rutile crystal can be described by the formula

$$Ti^{4+}\,(e^-)_{2x}\,(A.V.)_x\,O^{2-}{}_{2-x}$$

This formula brings out the fact that the defective crystal is not an insulator but that it contains "available" electrons which are responsible for its conductivity. Because of the gain of entropy a rutile crystal at high temperature can take Ta_2O_5 into solid solution. The substitution of Ta^{5+} ions for the same number of Ti^{4+} ions increases the configurational entropy of the crystal but it also increases the positive charge of its cationic lattice. In order to retain electroneutrality such a crystal has to increase the number of O^{2-} ions and the number of available electrons. It was found that the addition of 1 mol per cent Ta_2O_5 or Cb_2O_5 increases the specific conductance of rutile by a factor (Table I) of about 5000.

This change in electronic conductivity is the result

of an increase in the number of available electrons but this change is accompanied by an increase in the number of O^{2-} ions. The latter is the important feature for nucleation because it means that a crystal which has been "doped" with Ta_2O_5 has a smaller number of anion vacancies and its lattice is less defective. Through the addition of Ta_2O_5 a crystal of TiO_2 can become a semiconductor which has no vacant anion sites as we can see from the formula:

$$Ti^{4+}{}_{1-y}\ Ta^{5+}{}_{y}\ (e^-)_y\ O^{2-}{}_2$$

This type of substitution is, therefore, a means to decrease the defectiveness of a semiconducting oxide and to enforce glass formation.

Introducing into the lattice of rutile an oxide which lowers the positive charge of the cationic lattice was found to have the opposite effect. Y_2O_3, for example, decreased the conductivity of the rutile to one tenth of its original value. Such a "doped" rutile develops more vacant anion sites and has a smaller number of electrons in its conductivity band. Table I gives some of the experimental data. As a rule cations with a charge higher than that of the Ti^{4+} ion increase and cations with lower charge decrease the conductivity. This rule, however, has two exceptions. B_2O_3 and BeO have lower charged cations than TiO_2 but their addition to rutile increased the conductivity. The B^{3+} and the Be^{2+} ions have the electron configuration of the helium atoms. The smaller size must enable such an ion to assume interstitial positions. Rather than occupying regular cation sites these ions do not replace Ti^{4+} ions but they add to the positive charge of the cationic lattice which in turn increases the number of available electrons and the number of O^{2-} ions. B_2O_3 and BeO affect the lattice in the same way as Ta_2O_5 or P_2O_5, they decrease the concentration of anion vacancies.

The effect which a foreign ion will have on a defective crystal cannot always be predicted because a lattice can respond to a foreign ion in more than one way. However, by studying the electronic conductivity[40], the chemical reactivity of the semiconductor with oxygen[41], and the rate of sintering[39], it is possible to determine the nature of the change. We see from Table I that Cb_2O_5, Ta_2O_5, P_2O_5, B_2O_3, etc. participate in the structure of rutile in a way which raises the positive charge of the cationic part of the lattice. From this observation we conclude that a crystal containing one or more of these oxides will melt more like a perfect crystal because it should have less vacant anion sites than pure TiO_2. The question, however, remains open whether or not one can apply this crystal-chemical treatment of semiconductors to the liquid state. As far as the electronic part is concerned we know that liquid semiconductors exist, but we are not interested in the electronic aspects of "doping" but in the effect upon the concentration of lattice vacancies. Is it permissible to use the concept of vacant sites in the description of the structure of glasses?

Table I

EFFECT OF FOREIGN ATOMS ON THE ELECTRONIC CONDUCTIVITY OF RUTILE

(After G. H. Johnson and W. A. Weyl)

Addition 1 mole %	Specific Conductance $ohm^{-1}\ cm^{-1} \times 10^{-9}$	Factor
	60	1
Cb_2O_5	330,000	5,500
Ta_2O_5	250,000	4,166
Sb_2O_5	50,000	833
P_2O_5	61,000	1,020
WO_3	240,000	4,000
Al_2O_3	23	0.4
Fe_2O_3	27	0.5
Ga_2O_3	23	0.4
Y_2O_3	7	0.1
B_2O_3	370	6
MgO	30	0.5
CaO	4	0.07
CdO	30	0.5
BeO	1,500	25

2. *Liquid Structures*

Our discussion of the compatibility of some oxides with silica was based on the concept that the symmetry of the environment of a cation of low polarizability, in particular its coordination number, is a feature which dominates not only the structure of crystals but even that of liquids. It is well understood that some liquids resemble crystals much more closely than they resemble a compressed gas but somebody might still question the validity of an approach which is based on a very close resemblance of the short range order around cations in glasses and in crystals. When V. M. Goldschmidt[42] developed modern crystal chemistry he was fully aware of the importance of the symmetry of the first coordination sphere of a cation upon the stability of structures. He visualized that problems concerning the symmetry will arise and he suggested studying the environmental conditions of cations by means of color indicators.

He wrote: "Ionic lattices which contain colored ions of the rare elements like trivalent praseodymium, neodymium, samarium, europium, or erbium show absorption spectra consisting of rather sharp lines. These spectra vary from crystal to crystal and it should be possible to obtain quantitative data concerning the state of polarization of the crystal by interpreting the shift or suppression of certain lines. It should be possible, so to speak, to measure the ionic fields by their Stark effects on the ions of the rare elements. This method can also be applied to any other crystal if only some of the metal ions are replaced by rare earth ions of suitable size. Small amounts of these rare elements might be used as indicators which help to determine the strength and orientation of the electric fields present in the crystal."

The use of color indicators for deriving atomic structures is not limited to crystals but can be extended to glasses. K. Rosenhauer and F. Weidert[43] followed Goldschmidt's suggestion and introduced Nd_2O_3 into glasses of different compositions and measured their absorption spectra. Nd_2O_3 is incompatible with SiO_2 but it can be

made compatible by means of alkali oxides. The sharpness of the spectra is a measure of the symmetry of the environment which the Nd^{3+} ions can achieve. Thus for the alkali silicate glasses the sharpness and the fine structure of the absorption spectra was found to increase from the lithium to the rubidium silicate glass. For a series of alkaline earth oxide-potash-silicate-glasses the sharpness of the spectra was found to increase from MgO to CaO to SrO and was greatest for the BaO glass. Increasing polarizability of the O^{2-} ions increases the compatibility of the Nd_2O_3 with silica and the symmetry of the Nd^{3+} ions within their first coordination spheres.

Glass melters are well aware of the fact that the replacement of Na_2O by K_2O and the replacement of CaO by BaO or even more so by PbO produces more "brilliant" colors, i.e., sharper absorption spectra.

W. A. Weyl and E. Thümen[44] used Ni^{2+} and Co^{2+} ions as color indicators for following the coordination changes which occur if the temperature or the composition of a glass is changed. In an environment of low polarizability, e.g., in a lithium silicate or a boric oxide glass, Ni^{2+} ions assume sixfold coordination. Glasses which contain O^{2-} ions which are more polarizable favor fourfold coordination. It is significant for the symmetry requirements of cations that in those glasses which contain O^{2-} ions of intermediate polarizability an equilibrium is established between the two color centers, e.g., between well defined NiO_4 and NiO_6 groups. Also, heating a glass shifts the equilibrium from XO_6 to XO_4 groups but does not produce some asymmetrical NiO_5 groups as one might expect within a random structure.

The absence of visible light absorption reveals that the Pb^{2+} ions in a potash-lead silicate glass assume positions in a symmetrical environment. The low symmetry of the PbO_8 groups in crystalline PbO gives rise to its yellow color but this absorption of the polarized Pb^{2+} ion in the short wave part of the visible spectrum is not retained in the glass at ordinary temperature. At high temperatures lead glasses are brown because the Pb^{2+} ions in their thermal diffusion pass through positions in which they are polarized by an asymmetrical environment.

Recently, T. Bates and R. W. Douglas[45] applied the ligandfield theory to the absorption spectra of Cr^{3+} ions in solutions, crystals, and glasses and arrived at the conclusion that the Cr^{3+} ions in glasses are symmetrically surrounded by six O^{2-} ions. The authors wrote: "The present work shows without doubt that Cr^{3+} dictates it own coordination."

We may summarize the situation and state that Nd_2O_3, and Cr_2O_3 are not compatible with silica because these oxides contain cations which, in an environment of low polarizability as offered by silica, demand a symmetrical octahedral environment. Their screening demand can best be met if K_2O and PbO are introduced into the system. The preference of glass melters for potash lead silicate as a base glass for producing brilliantly colored glasses may be explained on the same basis: The flexibility of the polyhedra around K^+ and Pb^{2+} ions makes it possible for the CrO_6 and NdO_6 octahedra to assume their highest symmetry which, in turn, leads to sharp absorption spectra.

In contrast to soda lime glasses a heavy lead glass can dissolve substantial amounts of chromium oxide. On cooling, large plates of Cr_2O_3 crystallize out from such a melt. This process has been used for decorative effects: chrome aventurine glass.

Cations such as Ni^{2+}, Co^{2+}, or Cr^{3+} have rigid coordination and symmetry requirements. The flexible polyhedra around the alkalies, in particular the K^+ ion, and around highly polarizable cations, such as Pb^{2+} ions, increase the compatibility and permit Cr_2O_3 to go into solution.

Our concept of the structure of a glass-forming liquid as one without a major concentration of holes and fluctuating fissures is responsible for our different approach to the subject of compatibility. Most authors who wrote on the subject of liquid immiscibility were looking for explanations for the incompatibility of, let us say, MgO and SiO_2. We take it for granted that the tetrahedral structure of silica cannot accommodate a major concentration of a cation which demands sixfold coordination up to temperatures of 2800°C, the melting point of MgO. According to our views no holes are available in a silica structure which can accommodate a major concentration of structural elements which are foreign to its tetrahedral structure. In a glass-forming liquid a "hole" can become a structural element under conditions which are analogous to those in crystals. For example, if one replaces some K^+ ions in KCl by Sr^{2+} ions one produces a crystal which contains "holes" or more specifically vacant cation sites because a Sr^{2+} ion replaces two K^+ ions as far as the charges are concerned but only one as far as the lattice sites are concerned.

$$K^+_{1-2x}\, Sr_x^{2+}\, (\text{Cat. Vac.})_x\, Cl^-$$

In melts which resemble in their structures those of the crystals, holes can be produced by proper additions. T. Baak[46] found that the electrical (ionic) conductivity of fused CaF_2 can be increased considerably by adding to the molten CaF_2 between 5 and 10 mol per cent CaO. This effect of CaO is most remarkable because CaO by itself has a very low ionic conductivity.

T. Baak offers the following explanation for this interesting phenomenon. Because of the equal size of F^- and O^{2-} ions the "liquid lattice" of the CaF_2 accommodates some O^{2-} ions which take the place of the same number of F^- ions. Because of the higher charge of the O^{2-} ions the lattice develops anion vacancies in the same fashion as the introduction of $SrCl_2$ into the crystal of KCl causes the formation of cation vacancies. Baak who supported his explanation by density measurements found that, analogous to defective crystals, the concen-

tration of these vacancies has a limit. The maximum number of vacancies which the liquid structure can support decreases with increasing thermal agitation because the liquid lattice breaks down. Baak's concept is of paramount importance for the constitution of liquids and glasses because it gives the glass technologist an opportunity to draw information from a field which is better understood than the structures of liquids, namely, the structures of defective oxides.

Our treatment of the kinetics of melting suggests that it is possible to change the concentration of vacant lattice sites by "doping" the melt and, thus, to increase its tendency to form a glass.

Examples of Chemically Enforced Glass Formation

Our new approach to the rate of nucleation and the conditions which lead to glass formation among simple inorganic substances opened up new possibilities of obtaining glasses. V. M. Goldschmidt discovered the glass-forming ability of beryllium fluoride and attributed it to its similarity with silica in particular to the fourfold coordination of the Be^{2+} ion.

When lead fluoride, PbF_2, is melted in a platinum crucible and the melt is allowed to cool it crystallizes. Prior to our present concept of glass formation, when asked why we cannot obtain a PbF_2 glass analogous to the BeF_2 glass we would have answered that the Pb^{2+} ion is too large to enter fourfold coordination. Under the misapprehension that tetrahedral coordination is a prerequisite of glass formation we would have thought it is impossible to obtain a glass which is essentially lead fluoride because the PbF_2 cannot form a non-periodic tetrahedral network analogous to BeF_2 nor can it impart glass formation to a more complex system unless some glass formers such as B_2O_3 are incorporated as major constituents. Today when asked the same question we would answer that the fluoride of lead is not suitable for glass formation because all lead compounds are likely to form structures with vacancies and such defective structures nucleate easily because of their mobility imparted by fluctuating fissures. Lead oxide cannot form a glass, but an addition of an oxide which contains noble gas-type ions of high field strength and low polarizability makes PbO a glass former because it lowers the defect concentration. We do not assume that the addition of SiO_2 and P_2O_5 force upon the PbO a tetrahedral structure but we postulate that the structures of lead phosphates or lead silicates are characterized by low defect concentrations because the neonlike P^{5+} and Si^{4+} cores have rigid coordination requirements and will not tolerate a major concentration of vacant anion sites which are conducive to fluctuating fissures and fluid melts.

The same principle can be applied to lead fluoride. Glass formation can be enforced in spite of a non-tetrahedral structure. Melting PbF_2 in a glazed porcelain crucible produces a glass because the few per cent of Al_2O_3 and SiO_2 which go into solution prevent the system from forming a high concentration of vacancies and thus lower the viscosity and the rate of nucleation. This experiment with PbF_2 is analogous to those performed by J. E. Stanworth[48] with TeO_2 and by H. Wondratschek[49] with Pb_2GeO_4.

J. E. Stanworth[48] found that melting TeO_2 in a gold crucible did not produce a glass, but melting it in an alumina crucible introduced a few per cent Al_2O_3 into the molten TeO_2 which was sufficient to enforce glass formation. In this particular case we know from X-ray diffraction studies that vitreous TeO_2 has the same octahedral structure as the crystal.

The electron configuration of the Ge^{4+} ion is more conducive to defect structures than that of the Si^{4+} ion. As a result lead orthogermanate forms a defective structure which in contrast to the lead orthosilicate cannot be obtained in the glassy state. L. Merker and H. Wondratschek[49] found that small additions of Al_2O_3 enforce glass formation.

The experiment of H. Rawson[50] who enforced glass formation of V_2O_5 by relatively small addition of P_2O_5 belongs into the same group. Alloying, so to speak, the semiconductor V_2O_5 with P_2O_5 produces a solution which cannot tolerate a major concentration of defects and consequently, it will not nucleate on cooling but form a glass.

According to the conventional concepts ferric oxide is not a glass former because the Fe^{3+} ion requires sixfold coordination. In contrast to the existence of calcium aluminate glasses no vitreous ferrite has been reported. The electronic structure of the Fe^{3+} ion is conducive to the formation of defective structures (magnetite) but that of the Al^{3+} ion is not. By combining Al_2O_3 and Fe_2O_3, H. C. Hafner, N. J. Kreidl, and R. A. Weidel[51] succeeded in obtaining stable infrared-transmitting glasses which were essentially aluminates and ferrites of alkaline earth oxides. Also the studies of N. L. Bowen, J. F. Schairer, and H. W. V. Willems[52] in the ternary system Na_2O-Fe_2O_3-SiO_2 revealed glasses the compositions of which leave no doubt that the Fe^{3+} ions must contribute to glass formation.

Some additions also aid glass formation by lowering the liquidus temperature of the system but in essence we may describe this type of enforced glass formation as the alloying of an oxide or a flouride with another compatible oxide which does not tolerate a major concentration of lattice vacancies and fluctuating fissures.

The additions which can enforce glass formation in systems such as Fe_2O_3, V_2O_5, TeO_2, Pb_2GeO_4, or PbF_2 were oxides which contained cations of the neon gas type namely the Al^{3+}, Si^{4+}, and P^{5+} ions. These oxides belong to the conventional glass-forming oxides.

For many years scientists who were engaged in the development of new glasses based their work on the principle that a glass-forming oxide, either SiO_2, P_2O_5, B_2O_3 or a combination of these oxides, had to be an essential and a major constituent of the glass.

The development of most commercial glasses was based on this principle. G. W. Morey[53] opened up an entirely new and unexpected field of glass compositions, some of which, e.g., a mixture of TiO_2 and Ta_2O_5, were based on oxides which by themselves could not form a glass. Other glass compositions contained B_2O_3 but, even in those cases, the quantities of B_2O_3 were much too small to provide a continuous network of BO_4 tetrahedra. Morey's glasses were modified later in the Eastman Kodak Research Laboratories, in particular, by L. W. Eberlin[54] and P. F. DePaolis[55].

Thus, a new field of glasses was discovered which was based on oxides such as TiO_2, Ta_2O_5, ThO_2, WO_3, and La_2O_3, none of which could form a stable glass by itself. According to our concept the presence of Ta_2O_5 prevents TiO_2 from developing a major concentration of vacancies so that TiO_2 melts as a "perfect" crystal forming a melt which is more likely to solidify as a glass than one of pure TiO_2 which has many "holes" and fluctuating fissures. This glass does not have a tetrahedral structure but likely contains both the Ti^{4+} and the Ta^{5+} ions in sixfold coordination.

4. The Application of Color Indicators to Structural Problems

In our efforts to explain why additions of B_2O_3, P_2O_5, or Ta_2O_5 make it possible for TiO_2 to form a glass we were guided by the effects which these additions have upon the electronic conductivity to TiO_2. Additions which increase the electronic conductivity to TiO_2 also increase the number of O^{2-} ions per mole TiO_2 or more precisely they lower the concentration of vacant anions sites which in turn favors glass formation.

Most glass technologists are not familiar with the electronic conductivity of defective crystals but they are well acquainted with another electronic property of solids, i.e., the color or the light absorption, which also responds to lattice defects. Therefore, a brief discussion of some color phenomena might help to achieve a better understanding of our reasoning. No doubt some glass technlogists might have wondered about some everyday observations in the glass plant and asked themselves questions such as: "How is it possible to produce a green glass by adding black chromium ore to the batch? How can additions to the batch of black cobalt oxide or pyrolusite produce blue and amethyst colored glasses respectively? Maybe it is even more surprising to find that a colorless crystal glass is obtained by using the strongly colored Pb_3O_4 as a major batch ingredient. In all these cases the ions which are responsible for the light absorption of the batch ingredients are moved from defective crystals or crystals which have a low symmetry into a much more symmetrical environment. The Cr^{3+}, Mn^{3+} or Pb^{2+} ions in glass have light-absorption similar to their aqueous solutions.

Ceramists familiar with pigments can make similar observations. The red or brown Fe_2O_3 turns black on heating because it changes into magnetite, which has a defect structure. By combining Fe_2O_3 with silica one can prevent the formation of a defect structure and, thus, produce stable salmon colors. The black oxide of manganese has a defect structure. Alloying Mn_2O_3 with Al_2O_3 eliminates the defects so that its solid solution with alumina gives the desirable manganese-alumina pink. Alumina also changes the black cobalt oxide into a blue pigment.

Until a few years ago chemists knew that tetravalent praseodymium only occurs in the black defective crystal. Using the proper host lattice, e.g., zircon, made it possible to stabilize the compound PrO_2 as a solid solution free of vacancies and, thus, produce the brilliant praseodymium yellow.

In precisely the same way we picture the ability of P_2O_5 to stabilize the structure of V_2O_5. The high field strength of the P^{5+} core, its low polarizability, and its neon structure are not favorable to the formation of vacant lattice sites. The electronic structure of the V^{5} core, on the other hand, permits lattice vacancies to form and the latter induces a disproportioning of the binding forces which is conducive to nucleation. Hence, alloying V_2O_5 with P_2O_5 lowers the concentration of vacancies causes the binding forces within the melt to become more uniform, and makes the system conducive to glass formation.

At the present time physical chemists are developing a new and a more quantitative approach to the interpretation of the absorption spectra of compounds which contain elements of the transition group: the "ligand field" theory. T. Bates and R. W. Douglas[45] recently started to apply this approach to the absorption spectra of chromium in glasses and solutions. There is definite hope to make major progress in the search for a better picture of the atomic structures of glasses through the application of the ligand field theory to color indicators. In the past W. A. Weyl[28] used color indicators as a qualitative tool for attacking structural problems but there is no reason why this approach could not be made quantitative. Modern optical instruments make it possible for scientists to make precise measurements of absorption spectra and the ligand field theory should help in their interpretation. With respect to our present approach to the structure of glasses, the light absorption has already given us some valuable clues which shall be mentioned.

(1) The absence of long range order in a glass does not seem to seriously interfere with the symmetry of its structural units. For a lead silicate glass, for example, the absence of visible light absorption at low temperature reveals that the Pb^{2+} ions participate in such a glass as symmetrical polyhedra, probably PbO_6 groups. At ordinary temperature such a glass has no major concentration of "defects" comparable to the lattice vacancies of crystals. This type of defect develops in and above the softening range so that the color of the glass approaches that of the brown oxide PbO which contains polyhedra of a lower symmetry.

(2) In some crystals the coordination number of the cation decreases with increasing temperature, e.g., for the Ge^{4+} ion in GeO_2 from six to four. This change takes place as a cooperative maneuver and causes the rutile-like GeO_2 to change into the high temperature quartz form.

The color indicators Co^{2+} and Ni^{2+} reveal that this type of change can also occur in a glass on heating. However, the lack of periodicity in the glass makes it possible for these ions to establish equilibria between XO_6 and XO_4 groups. The fact that the change of the coordination does not lead to a gradual transition from XO_6 to XO_5 and XO_4 groups reveals the importance of the symmetry within glasses.

(3) The same color indicators also reveal that the change of coordination from six to four is enhanced by additions of alkali oxides. Lithium oxide has been found to be the least and potassium, rubidium, and cesium oxides the most effective additions. This phenomenon can make oxides, e.g., NiO, CoO, or TiO_2, compatible with silica because it can change XO_6 octahedra into XO_4 tetrahedra.

(4) The absorption spectra of Nd^{3+} ions reveal that the presence of polarizable ions makes the NdO_6 groups compatible with the SiO_4 groups. Among the alkali oxides, the highest compatibility for Nd_2O_3 with SiO_2 is achieved by those additions which introduce cations with the lowest field strength (K^+, Rb^+, Cs^+) whereas the cation with the highest field strength (Li^+) is the least effective.

Among the oxides of divalent elements PbO is by far the most efficient constituent whose addition to a glass improves the compatibility of the Nd_2O_3 with SiO_2.

(5) According to the findings of K. Rosenhauer and F. Weidert[43] the absorption spectrum of neodymium signals any change of the structure which affects the stability of the glassy state. Any change of the composition which increases the tendency of the glass to devitrify also blurs the otherwise sharp absorption bands of the Nd^{3+} ions.

IV. SUMMARY

The strict coordination requirements of the Si^{4+} core with respect to O^{2-} ions causes quartz to melt as a "perfect crystal," i.e., without developing a major concentration of vacant lattice sites. This feature which accounts for the stability of vitreous silica is responsible for its incompatibility with most other oxides. Compatibility is primarily the result of a geometrical condition and as it involves a gain of entropy it increases with increasing temperature. Oxides which contain cations which in combination with O^{2-} ions of low polarizability demand a higher than fourfold coordination are not compatible with silica. Cations which have a high polarizability, e.g., Ba^{2+} and Pb^{2+} ions, are more compatible with SiO_2 than MgO and CaO. The addition of a third oxide which introduces polarizable O^{2-} ions, e.g., Na_2O, increases the compatibility with silica. The complexity of this phenomenon, in particular the effect which the absolute temperature has upon the coordination requirements of cations as well as on the entropy of the system, does not permit us to bring the compatibility relations on a quantitative basis. However, the use of color indicators permits us to study compatibilities and to measure the stability of a system in vitreous condition.

Incompatibility in a silicate system leads to heterogeneity, either the crystallization of one of the oxides, the formation of two immiscible liquids, or the formation of a gas.

The effect which the temperature has upon the compatibility of glasses is used for producing color effects and opacity. The nucleation and crystallization of a compound from a complex glass can be the result of: 1. An electrostatic interaction between ions of different charges as in fluoride opal glasses. 2. A mutual polarization between a non-noble gas-type cation and a highly polarizable anion as in the selenium ruby glasses. 3. An increase of the coordination number of a cation with decreasing temperature as in glasses which contain TiO_2 and similar opacifiers.

The form in which crystals precipitate from a glass on cooling or reheating depends upon the defect concentration of the system. Compounds which are likely to form semiconductors such as CdS, TiO_2, and MoO_3 show a high rate of nucleation which favors the formation of colloidal and opacifying phases; whereas the precipitation of silica and silicates is governed by very low nucleation rates so that it leads to few but relatively large crystals (stones, devitrification).

Crystals which melt because they develop a high concentration of defects on heating, in particular the oxides of the transition elements, are unsuitable for glass formation because their melts are fluid due to numerous fluctuating fissures. The crystal chemistry of defective structures is briefly discussed and it is demonstrated that the proper additions can make compounds such as V_2O_5, TiO_2, PbF_2 glass formers.

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Bibliography on Glass Structure*

PART VIII

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η, electrical resistance, volume change, n, d and dielectric constant versus temperature show two transition temperatures. One at low temperature between viscous and brittle stages and second at high temperature between viscous and fluid stages. Materials in glass state have practically same property as m crystalline state. More arguments from association, frozen

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equilib. and thermodynamic equations. Changes in glass state are *intra*-molecular while in gas, liquid and solid they are *inter*-molecular.

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The results of numerous researches upon substances in the glassy state are reviewed. Attention is directed to the scientific aspects of the subject with little reference to the practical side of glass manufacture. Glasses studied were chosen rather because of their suitability for the investigation than because of their practical utility. Most of the work was done upon organic glasses softening between 0 and 100°C, but Tamman states that the general results may be carried over into the field of the technically important silicate glasses where the higher temperatures required increase the experimental difficulties encountered. The first half of the book discusses the formation of crystallization centers, the linear rate of crystallization in supercooled liquids, and the changes which occur in all the physical properties of a glass as its temperature is increased through the interval in which it softens. It is shown that for normal glasses the physical properties in general undergo rapid but continuous changes in the interval between the temperature at which the glass ceases to be brittle and that at which it can first be drawn out into threads. The behavior of glasses under high pressures is discussed.

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The glassy state is a general property of matter. The abnormal properties of glasses are general properties of substances in the glassy state. In the abnormal interval, aggregation of the molecules of liquid takes place accompanied by the loss of forward motion of the molecules. The change of physicochemical properties of glasses in the abnormal interval follows the Maxwell curve of distribution. The abnormal interval is a result of different velocities of motion of separate molecules of liquid. At a viscosity of 10^{13}, all substances in the glassy state are in corresponding states; therefore a connection between melting temperature and $T = 10^{13}$ is observed. Below $T = 10^{13}$, the process of crystallization is impossible. Below $T = 10^{13}$, from the kinetic point of view, the molecules of glass are in the same position as in crystals and therefore may reveal elastic properties, brittleness, etc.

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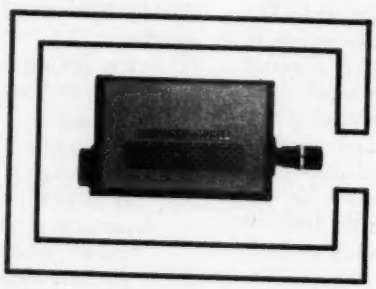
The mechanisms of viscous flow and of electrolytic conduction in liquids have been examined to show the significance of the activation energy which is evaluated from the temperature coefficients of viscosity and electrical resistivity. It is shown that the high numerical values characteristic of silicate glasses arise from the ionic character of the liquid, the small coordination number (4) for silicon, and the high electric change on the ions. Below the softening range, a glass is not necessarily stabilized and its properties depend upon its history.

(To be continued in March)



SEE IT HOT . . . AND SAVE

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Fiber Glass in 1960

by ***H. E. Simpson,*** ALFRED UNIVERSITY

THE FIBER glass industry is apparently where the aluminum industry was 20 years ago. It is just now coming into its own as an important industrial raw material. The recent rise and prosperity of the glass fiber industry continue to follow the trend of past years but at a lesser rate. Sales records for 1960 have been conservatively estimated between 350 and 400 million dollars. Both sales and earnings picked up in August and September and showed a gain over the same months in 1959. It is predicted that the fiber glass business will grow 5 times as fast as the national economy in the next 5 years. It is believed that activities in the future will reflect new and growing opportunities for this industry.

A leading manufacturer has recently established a sales branch in the new state of Hawaii and a resident office in Europe to keep abreast of developments and current markets there.

There still is a shortage of textile-type glass fibers, stemming from the spectacular up-surge of demand following the 1958 recession. Some makers of reinforced plastics suddenly increased their orders by as much as 50 per cent. It has been forecast that shipments of fiber glass textile yarns alone will increase to about 250 million pounds next year and 700 million pounds in 1970, from only 80 million pounds in 1955.

In today's economy the demand for reinforced plastics is enormous. As for fiber glass boats, it has been estimated that 40 per cent of the 400,000 boats built last year were of the polyester-coated synthetic. Production jumped to 130,000 in 1959 from 85,000 in 1958 and a mere 16,000 as recently as 1956. It is also to be noted that many of the new boats are sturdy auxiliary sea-going racers up to 45 feet over-all. "Pound for pound," says one producer, "there's nothing that can beat fiber glass for strength and durability." Golf clubs, lamp shades, luggage, and furniture are also being made from fiber glass reinforced plastics, as are construction panels, truck bodies, bullet-proof vests, and nose cones for missiles.

Fiber glass producers, backed by an amazingly versatile product, highly efficient facilities, and aggressive research and promotion, enjoy bright prospects for the future.

Acoustical Headline for Cars

Johns-Manville, and Owens-Corning Fiberglas, working with American Motors are making a one-piece, molded fiber glass ceiling, the first major development in automotive ceiling components since the introduction of sewn fabric headliners in the early 1900's.

Made of compressed fiber glass insulation and woven fiber glass trim fabric combined in a single unit lamination, with a range of colors to suit any interior, the new product can be snapped in quickly by only two workmen on the automotive production line. Contoured to hold itself in place snugly under the automobile's metal top, it provides up to three-quarters-of-an-inch extra head room. Constructed without seams, it adds the beauty of an unbroken ceiling line and creates a feeling of greater spaciousness. It replaces sewn fabric liners held in place by a complicated system of wires. (See THE GLASS INDUSTRY page 563, October 1960).

Glass Fibers Aid Missile Development

The success of Atlas or Thor missiles, like jet aircraft, is also somewhat dependent on the durability of fiber glass. The liquid oxygen lines, which supply part of the fuel to the engine, are at a temperature under 400°F. below zero, and if they were not insulated with fiber glass, various mechanical components within the vicinity would freeze instantly. Inches away, fiber glass reinforced plastics may be in the combustion chamber for the fuel burning, at temperatures of 5000°F. or higher. Certain mechanical components may be actuated by compressed air stored in filament-wound accumulator bottles that are as light as aluminum, but as strong as steel. Other uses in high-temperature exposures are now in development and testing programs but cannot be discussed owing to security classifications.

As man probes further into outer space, and as jet transports increase their speeds (a MACH 3.0—2100 m.p.h.—transport is on the drawing boards and could be operational by 1965), design parameters and material criteria become increasingly critical. Material and processing research in all fields must keep pace and even forge ahead of airframe and missile production. To date, research in fiber glass technology has kept pace and has met almost every demand. Unfortunately, adhesives and binding materials are required which will

function under the same severe conditions as fiber glass.

As an example, to be resilient, fiber glass must be bonded together, and even though certain forms can operate up to 2000°F. in such applications, binders have not been found which will exceed 600°F. The same is true of coatings and plastic resins, which limit the use of fiber glass to less than one-third its potential maximum operating temperature. Development of a 1200°F. resin could well mean the replacement of aluminum, steel, or titanium outer skins on all missiles and airframes with fiber glass reinforced plastics. The weight and cost savings would be considerable. Scientists and technicians in every phase of the fiber glass industry are constantly in search of such materials and test every one that offers any promise of increasing operating temperatures.

Glass Fibers for Aircraft Industry

Airborne vehicles traveling at sonic, and higher, speeds require the use of virtually universal material, and only fiber glass satisfies most of the requirements of such a material. This material must meet one or more of the following criteria:* It must not burn, corrode, mildew, absorb moisture, sag, fail under vibration, or lose resiliency. It must insulate against heat and sound, but not against the passage of radar waves. It must be as light as down, but not sag, pack, shift, or settle out of place, causing voids in insulated areas with resultant failures of equipment, nor must it expand causing stresses in structural parts. Under vibration it must not "dust," causing airborne contamination which might result in failure of delicate instruments and guidance equipment.

Passengers in today's modern jet transports—the Douglas DC-8, the Boeing 707, the Lockheed Electra, and the Convair 880—seldom realize that without fiber glass insulation the passenger cabin could not be maintained at a comfortable 70°F., while the outside air temperature is often 70° below zero. Nor do they realize that the same fiber glass reduces jet engine noise levels, capable of deafening a person in seconds, to a low hum which does not interfere with normal conversation. When used for this purpose, it may be as soft as down, and a piece as large as an automobile can be held in one hand.

The methods of attachment, protection, and use of fiber glass insulation have gone through a never-ending progression of changes since its first use in aircraft. As an acoustical fuselage insulation, at first it was cut to size and glued to the inside surface of the fuselage. However, as improvements were made in aircraft capability, it became necessary to change to better methods of application. High altitude flying in the colder upper atmosphere caused moisture condensation, which filled the airspaces of the insulation and eventually increased the weight of the airplane. This was corrected by the use of vapor barrier films cemented to the fiber glass.

Currently the DC-8 uses a tufted blanket composed of 0.6 lb./cu. ft. "AA" flexible batting covered with a vinyl coated 2½ oz./sq. yd. nylon cloth. All seams are sealed to prevent moisture penetration. The Boeing 707 uses premolded "AA" panels, covered with mylar film and a vapor-permeable neoprene coated nylon cloth. The Convair 880 uses premolded "AA" 6 lb./cu. ft. stiff board covered with adhesive bonded 2½ oz./sq. yd. vinyl coated nylon cloth. The fiber glass before fabrication is identical in every instance, proving once again the universality of this material.

Although "AA" fiber is used exclusively in all commercial passenger airplanes, "B" fiber, which is coarser (0.00013" in diameter) is used in many cases where passenger comfort is not of prime importance, such as in military and private aircraft. The methods of application are identical with those of "AA" fiber—with only the cost and the end result being less.

One of the outstanding properties of fiber glass insulation board is its extreme resiliency without lateral flow, this flow being characteristic of rubber and other resilient materials. Another is its ability to resist permanent set at high temperatures. Both properties make it ideal for use as charge supports for rockets which are carried under the wings of military aircraft. Unlike rubber or steel, its resilient properties do not change over a broad range of temperature from −300° to + 600°F., and in certain instances up to + 1000°F. In that same military airplane, the pilot may be sitting on an ejector seat cushion which could absorb the shock of ejection—up to 25 times the force of gravity.

Many primary structural parts must be made from fiber glass reinforced plastics. On the Boeing 707, for instance, much of the empennage section is so constructed, since aluminum would fail under constant sonic vibrations of the jet engines; certain portions of the wings on most modern aircraft, are made of these fiber glass reinforced plastics because they have better performance characteristics than the metals they replaced. Air ducts in all aircraft assume many weird and complicated shapes, for which fiber glass reinforced plastics is an ideal material.

The basic materials in reinforced plastics are epoxy, phenol, and polyester resins, reinforced with fiber glass in one of its many forms—roving, chopped strand, glass textile cloth, or mats. Without the fiber glass, the resins are weak and brittle, and it is the combination of the two which gives them strength.

To insure the safety of all air-travel passengers, the Federal Aviation Authority recently ruled that all air transports must be equipped with weather-scanning radar. The radar antennas cannot project into the air streams, but they must be enclosed with some other non-metallic coverings (radomes) transparent to high-frequency radiations. Fiber glass meets these requirements. They must withstand air erosion at speeds above 600 miles per hour where air friction causes heating and deterioration

(*Continued on page* 104)

*See "Fiber Glass in the Space Age," by John A. Morgan and Leon McDuff, THE GLASS INDUSTRY, 41, June, 1960, Page 338.

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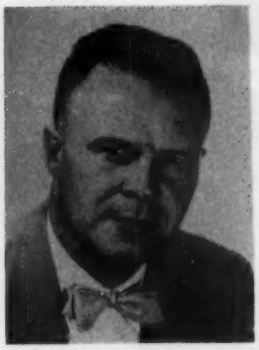


Dale Kleist

Dale Kleist

Appointed vice-president and European technical representative for Owens-Corning Fiberglas International, S.A., a subsidiary of Owens-Corning Fiberglas Corp. With the company since 1934, Kleist established residence in Lausanne, Switzerland, in December. He was formerly a member of the engineering development department for fiber glass insulation and textile operations, director of the general engineering department, general manager of the insulation and textile laboratories, and director of process and product development for insulation products. For the past four years, Kleist has been chief engineer in the process engineering department for insulation products.

Thomas M. McLaughlin

District sales manager for the newly-created Boston office of Pittsburgh Plate Glass Company's Fiber Glass Division, headquarters 13 Eaton Court, Wellesly Hills, Mass. Eugene M. Wheeler, Jr., has been appointed sales representative for the new district office. McLaughlin, who joined Pittsburgh Plate in 1949, has served for the past year as salesman for the fiber glass division's New York City office.

Everett E. Jones

Director of transportation, Owens-Corning Fiberglas Corp. Prior to joining the company in 1959 as general traffic manager (truck), Jones was manager of Detroit and Toledo operations for Merchants Motor Freight, Inc. He has also served as operations manager for Miller Transportation of Detroit, and traffic manager for Dura Co. before it became a division of the Detroit Harvester Co.

Gene Carney

Has been appointed sales manager, and Robert B. Lovell chosen to head the new product development group as manager of the development laboratory in a recent organizational expansion at Modiglass Fibers, Inc., headquarters at Bremen, O. Modiglas is a division of Reichhold Chemicals, Inc.

Robert L. Wardle

Manager of the new fiber glass engineering and supply division office and warehouse opened by Owens-Corning Fiberglas in Tucson, Ariz. He was formerly contract department manager with the engineering and supply office in Phoenix.

Slump in Boat Sales

A clearing out of excess inventory and less soundly financed builders has been forced by the overproduction of fiber glass boats in 1960. A 15 to 20 per cent increase anticipated last spring has not been met by most companies, with the result that the industry as a whole is still engaged in clearing out 1960 models. It has been predicted that it will be another year (1962) before the poundage of reinforced plastics going into boats will again reach the 71-million-pound level of 1959.

According to officials of the Molded Fiber Glass Co., the effect of this temporary setback will be a healthy one, with those companies capable of weathering business fluctuations, supporting programs of quality research, and financing improved merchandising and distribution surviving.

Ferro Corporation

Announced the completion of a quarter-million dollar plant for the production of fiber glass reinforcing materials and colorants for plastics in North Miami, Fla. J. Gerry Browne has been named manager of the new installation, and Leonard J. Tansky made supervisor of the plastics colorant division.

Gustin-Bacon Mfg. Co.

Reported increases of 9.4 per cent in sales and 2 per cent in earnings for the first quarter of the company's fiscal year ending December 31, 1960. Sales for the firm, manufacturer of glass fiber insulation, acoustical products, and organic fiber mat material, were $8,176,016, up from $7,426,566. Earnings after taxes totaled $557,574 compared with $546,576 in the like quarter a year ago. These earnings amount to 38 cents per share, as against 37 cents per share, both figures based on the presently outstanding capital stock. The company paid a dividend of 10 cents per share for the quarter.

Pittsburgh Plate Glass Internat.

And Algemene Kunstzijde Unie N.V. of Arnhem, Netherlands, will jointly establish a fiber glass plant in the Netherlands for the production of yarn and roving. Both organizations will hold a 50 per cent interest, and each will form a new company.

Pittsburgh Plate will contribute the technological knowledge, experience, and patents, and will be responsible for the erection of the plant and installation of equipment. A.K.U. will make available to the new company its fifty years' knowledge and experience as a producer of yarns and fibers.

Operations are expected to start in 1962, and the new plant's products will be sold in the Netherlands and abroad. Factory location will be announced later.

Owens-Corning Fiberglas

Has formed a subsidiary corporation, Owens-Corning Fiberglas International, S.A., George Cook III, manager of the company's International Division has been appointed president. He will also continue as manager of the International Division.

Fiberglas International will be responsible for marketing products outside the North American continent. The International Division, which previously handled these sales, will be responsible for sales to Canada and Mexico and to American customers for their shipment abroad.

Johns-Manville Corp.

Will expand its Waterville, O., fiber glass operations with 45,000 additional sq. ft. of manufacturing, warehousing and shipping space. Textile fiber glass production capacity will be increased by 40 per cent. New equipment will account for half of that increase. The remainder will come from improved operating efficiencies of existing manufacturing units.

Applications...

1961 Motor Boat Show

It is more evident than ever, this year, that fiber glass has captured a permanent segment of the pleasure boat market and will undoubtedly continue to make inroads on wood and aluminum —but at a lesser degree than in previous years.

A few boat dealers are still a little too enthusiastic about the advantages of fiber glass, and these few tend to suggest that no maintenance is needed.

That the Federal Trade Commission saw fit to hold a hearing during the Show is a very healthy sign. Although fiber glass is a very versatile material and does permit a freer design in boats, the laws of stress still pertain to this material, as they do to wood and aluminum. Just because a boat is made of fiber glass does not per se *mean it is seaworthy, regardless of design or construction.*

It is essential that the fiber glass boat manufacturers develop more rigid standards, and agree on them as an industry, if they hope to maintain and increase the consumer confidence which they now have.

Just about 50 per cent of the boats on display in New York last month at the 51st National Motor Boat Show were made of fiber glass. Of the 450 or more exhibits, 90 were sailboats. Among the many fiber glass boats on display were:

Douglass & McLeod, Grand River, O.
The Thistle (17 ft.) and the Highlander (20 ft.), both racing sloops. These are now being made in fiber glass as well as in wood.

Roberts Industries, Branford, Conn.
The Penguin (11½ ft.), a dinghy often seen in winter sailing.

Summer Boat Co., Amityville, N.Y.
A motor sailor (29 ft.), which, although principally a power boat, is equipped with a sloop rig. This is made of "Compoglas," part wood and part fiber glass.

Lone Star Boat Co., Grand Prairie, Tex.
The Vacationer cruiser (17 ft.) with two berths.

Aqua-Sport, Inc., Kansas City, Mo.
Sea Skimmer, a fiber glass "flying saucer," in which the sole passenger

lies face down in the stern, with feet in the water. It is powered by an electric motor or by a 6- or 8-hp outboard. Stearing is controlled by leaning and use of the feet.

Pearson Corp., Bristol R.I.
Two new inboard cruisers, 27 and 37 ft., and three sailboats, the Hawk day sailor (17 ft.), the Electra cruising sloop (22 ft.), and the Tiger Cat catamaran (17 ft.). The 37 footer draws 2 ft., has a 12-ft. beam, and sleeps six. The 27-footer is a sport fisherman and sleeps four.

Glasspar Co., Santa Ana., Calif.
Outboard runabouts ranging from 10 to 17 feet, and the Seafair line of cruisers in three models.

Bertram Yacht Co., Miami, Fla.
Flying bridge sports fishing cruiser (31 ft.) with a 9- by 12-ft. cockpit.

FIBER GLASS CHAIRS feature satin-chrome understructure, and compound curves designed to fit body contours for seating comfort. They are manufactured in both side chair and arm chair models.

Chairs: Brunswick Corp., 2605 E. Kilgore Rd., Kalamazoo, Mich.

EPOXY GLASS INSULATING MATERIAL has been developed for use where retention of high dielectric strength and flexibility under continuous class F temperatures is required. The "Irvington" brand epoxy-coated glass No. 2525 is claimed to be compatible with all class F magnet wires, Scotchcast electrical resins, and most other epoxy systems. The material will not contaminate or degrade transformer oils used in distribution transformers.

Epoxy Glasss Insulation: Minnesota Mining & Mfg. Co., Irvington Division, 6 Argyle Terrace, Irvington 11, N.J.

FIBER GLASS TRUCK PANELS, in use since 1954, are now standard with several body companies throughout the country. Applied early in production as overhead sliding doors on beverage trucks, for which purpose they are ideally suited, these panels have been credited with improved operation, greater durability, more uniform appearance, and easier installation.

During 1960, an estimated 39,250,000 pounds of fiber glass reinforced plastics went into parts for the transportation market. An increase of 16 per cent is forecast for 1961, and by 1966-67, this consumption is expected to reach 94,500,000 pounds.

Glass: Molded Fiber Glass Sheet Co., Ashtabula, O. Application: Timmons Metal Products Co., Columbus, O., Hesse Carriage Co., Kansas City, Mo., and J. A. Hackney & Sons, Inc., Washington, N.C.

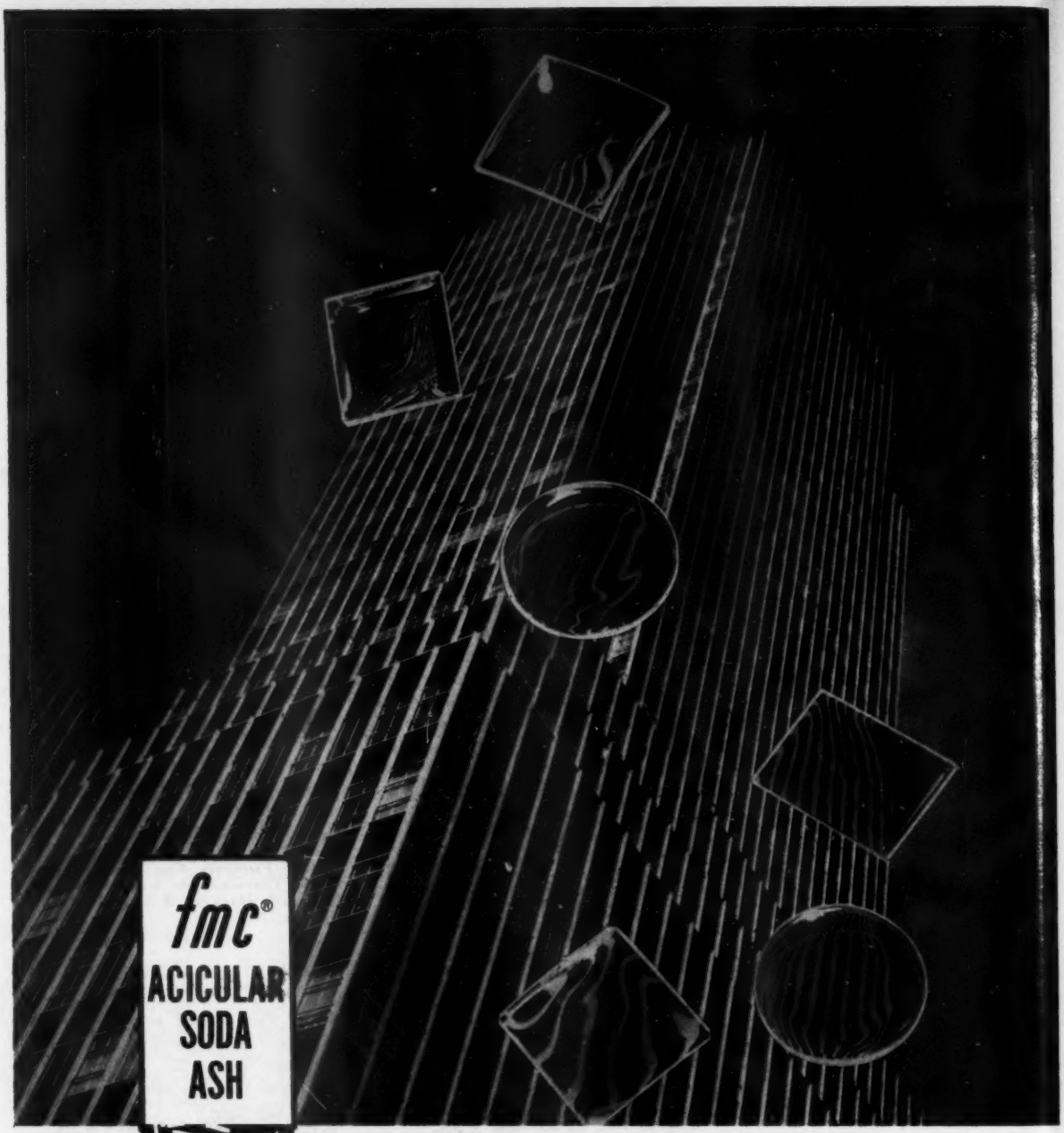
FIBER GLASS PATIO ROOFS are being produced with a distinctive panel shape that is said to provide better drainage and prevent leakage with minimum pitch. The sheets serve as protection from the elements and transmit a soft light.

Fabricator: Alsynite Div., Reichhold Chemicals, Inc.

CATALOGS RECEIVED

Fiber glass packing. (4 pages) A bulletin showing applications of "Glascushion," a resilient padding fabricated of very fine glass fibers held firmly together with plastic resin. This product can be molded to shape, fabricated, or cut in the packing department. Full specifications, including deflection and compression data, are listed. Write for bulletin TD-102.

Glass and Development: Fibrous Glass Products, Inc., subsidiary of Pall Corp., Alpa Plaza, Hicksville, N.Y.



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NEWS
IN THE GLASS INDUSTRY

Personalities...

Leonard G. Ghering

Richard E. Mould

Henry M. Dimmick

Dr. Leonard G. Ghering

Board chairman of Preston Laboratories, Inc., succeeding Dr. Frank W. Preston who has resigned but will continue to act as consultant to the laboratories. Formerly president and director of research, Dr. Ghering will devote most of his time to technical and scientific duties as senior glass technologist for the laboratory and consultant for major clients.

At the same time Dr. Preston will contine his own independent consulting practice for the glass industry and other clients.

Dr. Richard E. Mould, formerly vice president for research, is new president of the firm and director of research.

Henry M. Dimmick, proprietor of Dimmick Associates, designers and manufacturers of electronic and allied equipment, has joined Preston Laboratories as executive vice president. Prior to forming his company, Dimmick had been with Preston Laboratories from 1948 to 1952, followed by a one-year association with Brockway Glass Co.

Robert R. Lehnerd continues as vice president of equipment manufacturing and sales, and Russell D. Southwick, as assistant to the director of research and secretary.

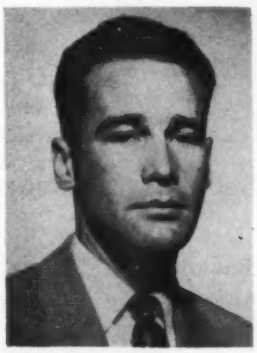
L. G. Bliss

Chairman of the board, Foote Mineral Company, a position which has been vacant since the retirement on November 30, 1960, of Gordon H. Chambers. Bliss will continue as president and will assume the new responsibilties in addition to his regular work.

Donald R. Tope

General manufacturing manager, Glass Division, Ford Motor Company. He will direct operations of the Dearborn and Nashville glass plants, and the Glass Division's staff manufacturing engineering, production programming and control departments, and technical center services. In addition, he will be responsible for providing technical services and assistance to Canadian glass operations.

Tope, with the company since 1945, was appointed manager of the manufacturing and plant engineering department of the Glass Division in 1958. He became manager of the division's engineering and research office in 1960, and is presently chairman of the company's glass coordination committee.



Donald R. Tope

Donald L. Harwood

President, Dearborn Glass Co. He had been with Fairbanks, Morse & Co. for 34 years where he was vice president of purchasing and traffic.

Herman R. Paulick, Jr., son of the founder of Dearborn Glass, is secretary and assistant to the president. He joined the company as assistant purchasing agent in 1956.

Richard J. Stone

Research and development supervisor in delay line section, Corning Glass Works—a new position. He will be responsible for theoretical and experimental investigation of delay line phenomena, as well as technical and market evaluation of resulting applications. Stone was previously a projects leader, research division, Curtiss-Wright Corp.

C. Wendell Holland

C. Wendell Holland, regional manager for Libbey-Owens-Ford Glass Co. in the Pacific region, died of a heart attack on December 4 at his mountain lodge on Skyline Drive, south of San Francisco. He was 56 years old. He had been regional manager for L-O-F in San Francisco since 1942, with responsibility for the company's district offices in Los Angeles, Seattle and Denver, in addition to San Francisco.

Donald R. Bush

Donald R. Bush

Product manager, glass division, Pemco Corporation, where he will coordinate the research production and product development of vitrifiable glass colors. Formerly with Vitro Manufacturing Co. and export division of Ferro Corp.

Norman J. Vang

Norman J. Vang

Vice president, manufacturing, Corhart Refractories Co. He was most recently assistant to the staff vice president of Corning Glass Works, the parent company.

Donald W. Shoemaker, manager of manufacturing since 1957, is now manager of manufacturing services.

Donald W. Shoemaker

Philip A. Gaebe

Philip A. Gaebe

Appointed to new position of product manager, refractories, for Kaiser Refractories & Chemicals Division, Kaiser Aluminum & Chemical Sales, Inc. He will be responsible for customer relations and for maintaing liaison between the Oakland headquarters and the field sales staff.

Harold B. Davidson, formerly manager of sales service, is now assistant to the general manager at Pittsburgh. A. S. Arcari, previously assistant manager, is manager of sales service for the Eastern Division.

William C. Quance

William C. Quance

Named plant manager for Brooks Instrument Co., Inc., manufacturers of flow meters, at Brooks Instrument Nederland, N.V., Veenendaal, Netherlands.

Karl Baumler

Elected vice president, manufacturing, Pittsburgh Corning Corp. Formerly manager of manufacturing, he will supervise current and future manufacturing facilities of the company's two plants in Sedalia, Mo., and Port Allegany, Pa.

Cyril B. Delgado

Cyril B. Delgado

Appointed manager of chemical sales, Calumite Company of Hamilton, O. With headquarters in Neshanic, N. J., he has been covering the glass field for the past two years as a manufacturers' agent. He was, prior to that, editor for many years of THE GLASS INDUSTRY.

The Calumite Company is now in a position to supply selenium, iron chromite, lime, iron oxide, copper oxide, and various other minor batch ingredients, in addition to "Calumite," a substance used chiefly in amber, emerald green, and fiber glass.

Howard E. Abrams

Laboratory manager, Pall Corp., and Norman Friedman, manager of purchasing. Military and industrial applications of the company's filters range from jet aircraft to atomic submarines, and from the manufacture of petrochemicals and pharmaceuticals to TV tube production lines.

J. H. Dennis

Manager of manufacturing, has assumed full responsibility for all manufacturing divisions and the operation of Bailey Meter Company's three Cleveland plants. He succeeds C. E. Sutherland, vice-president, who retired in December.

J. H. Dennis

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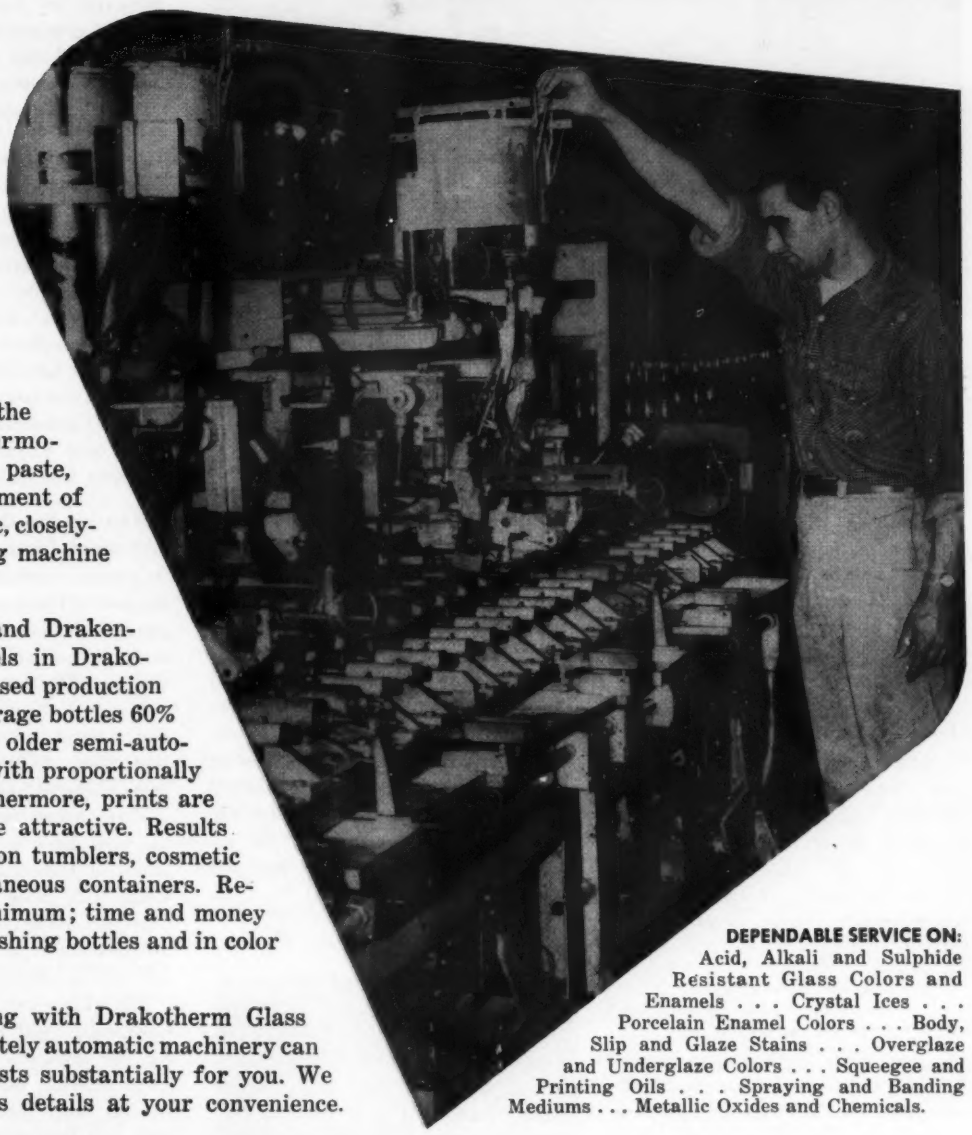

DRAKOTHERM, the quick-setting thermoplastic printing paste, led to the development of the fully automatic, closely-coupled decorating machine pictured here.

This equipment and Drakenfeld ACL Enamels in Drakotherm have increased production of decorated beverage bottles 60% above that of the older semi-automatic machines, with proportionally lower costs. Furthermore, prints are sharper and more attractive. Results are equally good on tumblers, cosmetic jars and miscellaneous containers. Rejects are at a minimum; time and money are saved in rewashing bottles and in color cost as well.

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Earl Flatter (standing), Overmyer vice-president, served as toastmaster at the Winchester banquet. Surrounding him are (left to right) Mrs. Max Hawkins, Mayor Ralph West, Mrs. West, and Mrs. Flatter.

Overmyer Mould Veterans Feted

An award banquet at which employees with 25 or more years of service were cited for their contributions to the company and its predecessor climaxed the 25th anniversary celebration at Overmyer Mould's Greensburg, Pa. manufacturing facilities. At this same time, the firm's main plant at Winchester, Ind., observed 40 years of operation.

Greensburg sales manager Richard Pershing was in charge of the banquet program, and the speakers were Lowell Roesner, Overmyer president, E. R. Flatter, vice-president, C. S. Manrose, secretary-treasurer, and C. M. Hawkins, sales manager.

Glass Containers Corp.

Building a new 10,000-sq. ft. central mold shop on company property at Fullerton, Calif. headquarters. When completed on or about April 1, the new shop will handle all new and replacement work, and the company's mold shops at Vernon, Hayward, and Antioch, Calif., will be reduced to repair work.

Vitro Corp. of America

Has purchased the minority interest (8.4 per cent) in its chemical subsidiary, Heavy Minerals Company of Chattanooga, Tenn., which was held by Pechiney Champagnie de Produits Chimiques et Electrometallurgiques of Paris, France.

In addition to all stock and notes held by Pechiney, Vitro has entered into a new royalty agreement which will run until December 31, 1974. This agreement gives Vitro exclusive United States and Canadian rights to all present and future Pechiney process and product patents involving rare earth chemicals, metals, alloys and related compounds. It also provides for a mutual exchange of know-how in the field between Vitro and Pechiney through 1974.

Vitro Chemical Co. was formed in 1959 by the merger of Vitro Uranium Co., Salt Lake City, and Heavy Minerals Co. The Salt Lake City operations were wholly owned by Vitro Corp., but its partial ownership of Heavy Minerals goes back to 1956.

Pechiney originally owned 20 per cent of Heavy Minerals, and the Crane Co., 80 per cent. Vitro purchased half the Crane interest in 1956 and the remaining Crane 40 per cent ownership in 1959. With the formation of Vitro Chemical Co., Vitro Corp.'s equity interest amounted to 91.6 per cent, with Pechiney owning the remaining 8.4 per cent which has just been purchased by Vitro.

American Potash & Chemical Corp.

And Societe D'Electro-Chimie D'Electro Metallurgie et des Acieries Electriques D'Ugine, as equal owners, have formed a new company, Seurobor (Societe Europeene du Bore) which will construct a $2-million facility to produce boric acid in France for the European market. The plant will be situated at Pierre Benite near Lyons, France, where Ugine produces perborate and other boron derivatives. Manufacturing operations will be under the management of Ugine.

Seuobor will market the boron derivatives through Borax & Chemicals, Ltd., European selling organization of American Potash & Chemical Corp. The ore to be processed will come from Turkish sources.

This new company is being formed, according to Peter Colefax, president of American Potash, and Rene Perrin, president of Ugine, because of the rapidly growing demand for boric acid and other boron products in the Common and European markets.

Knox Glass

Has new district offices at the Daily News Building, 220 East 42nd St., New York City. Donald J. Schile is district sales manager. The offices will also have accommodations for management executives who make frequent trips to New York: Dr. Arthur V. Wishart, president; Alexander W. Lanberg, vice president; Christopher H. Buckley, vice president, sales and marketing; Clarence R. Deible, vice president; and Edgar Mayfield, assistant treasurer and assistant secretary.

Columbia-Southern Chemical Corp.

A wholly owned subsidiary, became a division of Pittsburgh Plate Glass Company on January 1 and is now known as the Pittsburgh Plate Glass Company, Chemical Division.

Joseph A. Neubauer is vice president and general manager, chemical division; Chris F. Bingham is vice president, chemical sales.

This change in corporate structure has been made to consolidate the operations of Columbia-Southern Chemical Corp. with those of Pittsburgh Plate Glass Co. The general direction and management of the chemical operations will not be affected.

The trade name, "Columbia-Southern Chemicals," will continue to be used for the division's products which include chlorine, caustic soda, soda ash, solvents, silica pigments, chrome chemicals, and barium chemicals.

Chemical division plants are located at Barbeton, O.; Corpus Christi, Tex.; Natrium, W. Va.; Lake Charles, La.; Bartlett, Calif.; South Charleston, W. Va.; Jersey City, N.J.; and Midvale, O.

Present subsidiaries of Columbia-Southern Chemical Corp. have become subsidiaries of Pittsburgh Plate Glass Co.

NEW APPLICATIONS IN GLASS...

World's Largest Stained Glass Window Withstands Hurricane

The 7,000 sq. ft. of colored glass which decorate the facade of the American Airlines Passenger Terminal at Idlewild International Airport weathered Hurricane Donna last September without sustaining even minor damage. The giant window, 317 ft. long and 2½ ft. high, withstood 58-mph winds, proving that a massive area of leaded stained glass can endure destructive gale forces.

The window's durability is attributed largely to its lead frame construction. Built over the period of a year at the cost of $200,000, each of its panes and its 936 panel sections is set in lead comes, or flexible grooved rods. The supporting steel network of frames is wrapped with 2½-pound sheet lead and the lead seams burned to form a hermetic seal. The retaining frames are also composed of lead, and the panel sections caulked with thiokol.

Robert Sowers of New York, designer of the window, went to Germany to have "two-way" glass manufactured to match the colors on his palette. There he also had standard antique glass made in every color to be included in the window except blue. The blues were commissioned to an American firm.

Glass: Mittinger & Co., Darmstadt, Germany; Deutsche Spiegelglass, Mitterteich, Germany. Blue Glass: Houze Glass Co., Point Marion, Pa.

Glass Tube for Shock Wave Tests

A glass tube 12 ft. long and 6 in. in diameter is being used by the Boeing Scientific Research Laboratories, Seattle, Wash., in a study of high-temperature gasses. A head-on collision of two shock waves travelling 80 times faster than sound has been achieved in this hydromagnetic glass tube, believed to be the largest ever used in an experiment of this kind. Because the tube is transparent, still photographs can be taken of the colliding shock waves, which, at impact, brightly illuminate the Pyrex piping. The piping is made from the same borosilicate glass used for chemical and food processing lines, drainlines, and heat exchangers. As industry's most powerful shock tube, it is being used to help develop effective

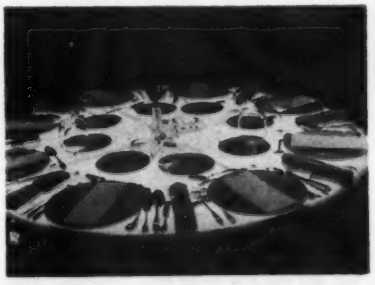
ion- and plasma-propulsion systems for use in space.

Glass: Corning Glass Works, Corning, N. Y.

Glass New Source of Light

Electroluminescent panels have been developed for a wide variety of applications in the field of architecture and interior design. These lamps are actually flat panels of glass coated with an electrical conductive film. When alternating voltage is applied, the panels glow with an intensity which, in some designs, can be regulated by means of a simple dimming device. The lamps, not unlike condensers in their construction, operate without filaments, tubes, or vapors, and generate practically no heat. Current drain is negligible, and there is virtually no possibility of lamp failure.

In the "Rayescent" lamp, a plate of specially coated glass is used as one



conducting service. A film of phosphor is placed next to the glass and the second metal conducting plate is applied to this layer. Finally, a moisture barrier is placed on the back of the lamp, and as current passes through, the phosphors are excited, emitting a soft, candlelight glow.

Imaginative and extensive use of electroluminescence is being made in the decoration of homes, offices, restaurants, cocktail lounges, lobbies, elevators, and public buildings. Because they are two dimensional, the lamps lend themselves in an unlimited number of ways to walls, ceilings, room dividers, table tops, mobiles, shelving, and furniture parts, as well as to dials and indicators.

"Rayescent" Lamps: Westinghouse Electric Corp., Bloomfield, N. J.

Glass Radiation Shield

The largest radiation window ever built will be used at the flight engine test facility operated at Idaho Falls, Idaho, by the General Electric Aircraft nuclear propulsion department. The transparent protective shield contains 17 panes of glass of varying thickness, is 8½ ft. thick, and weighs 18,000 pounds. It is designed for both neutron and gamma ray shielding.

Glass: Corning Glass Works, Corning, N. Y.

CATALOGS RECEIVED

Auto glass 1961. (104 pages) Complete glass specifications for all American cars, trucks, and busses, as well as for foreign vehicles. An interchangeable parts section catalogs makes and models of all automobiles using each NAGS pattern number. In addition, a safety glass area chart is included.

Shatterproof Glass Corp., 4815 Cabot Avenue, Detroit 10, Mich.

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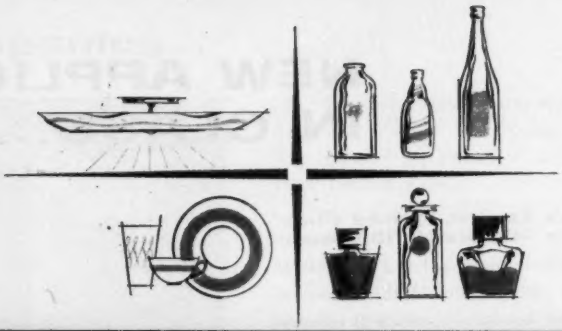

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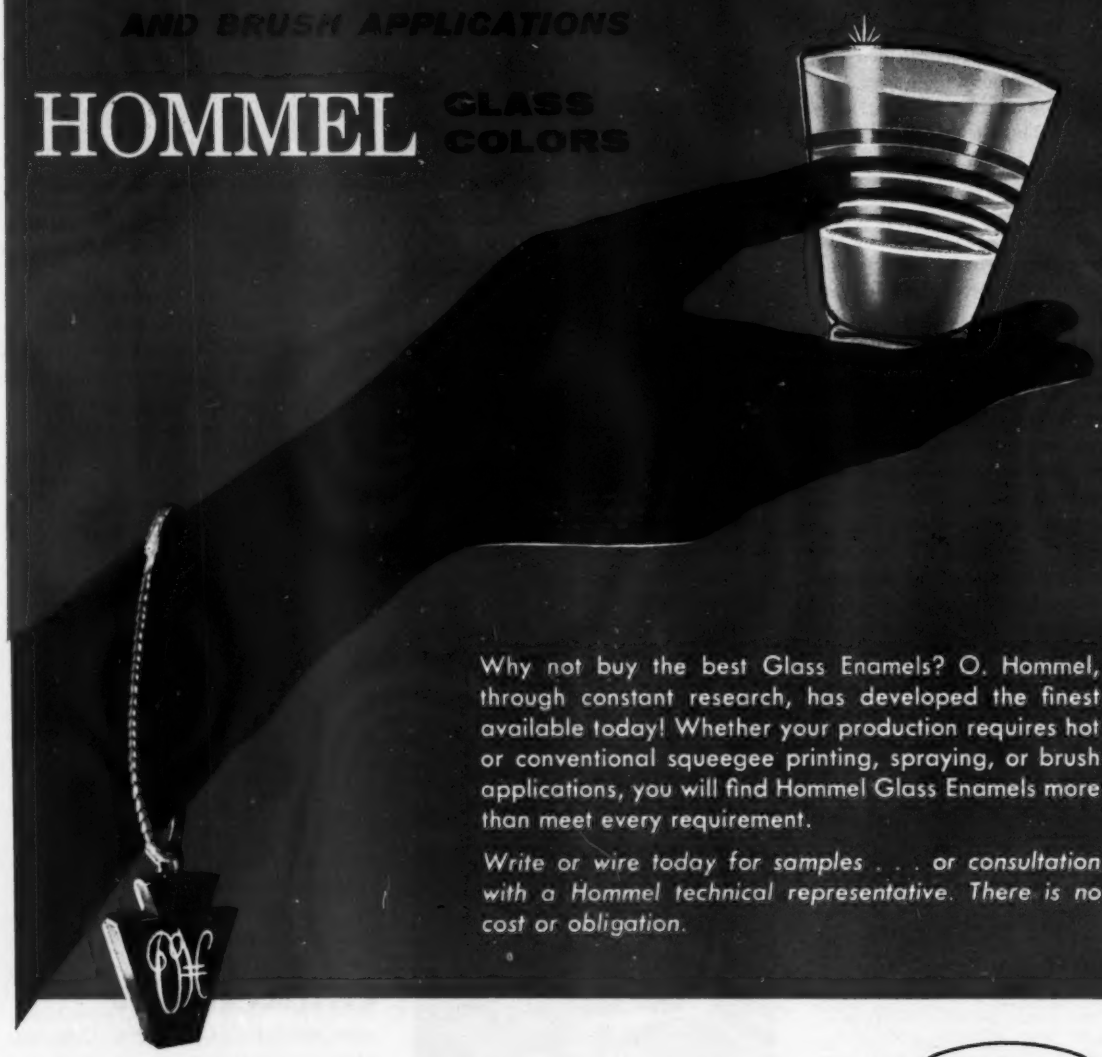

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NEW EQUIPMENT AND SUPPLIES

New Potentiometer

Last month the Brown Instruments division of Minneapolis-Honeywell Regulator Co. introduced a new industrial process potentiometer—the ElectroniK 1[illegible] line—which is based on an electromechanical strain gauge as the rebalancing element. Called the Stranducer (Fig. 1), the new element supersedes the conventional slidewire and has the advantage of infinite resolution; that is, there is no limitation on the number of points at which the potentiometer can come to balance, as compared to the number of turns, or convolutions, on a slidewire. And because the slidewire has been eliminated, there is less wear.

THE STRAIN GAUGE

The Stranducer works on the principle that a wire, when stretched, will change its resistance in proportion to its mechanical elongation. Because such a wire also changes its resistance with temperature, the gauge is designed to eliminate this temperature effect.

The design is such that four pretested looped wire strands, enclosed in an I-shape frame (Fig. 1), form the variable resistance legs of the measuring circuit, and their resistance varies in proportion to the tension applied to them. At zero position, the wires are in equal tension and are therefore of equal resistance. When the pivot arm rocks in one direction (i.e., forward), it increases tension on two of the wires and decreases it on the other two, and when it rocks in the other direction, the process is reversed. This device, in turn, is linked mechanically through sector and strap reduction stages and the drive cable in the balancing motor.

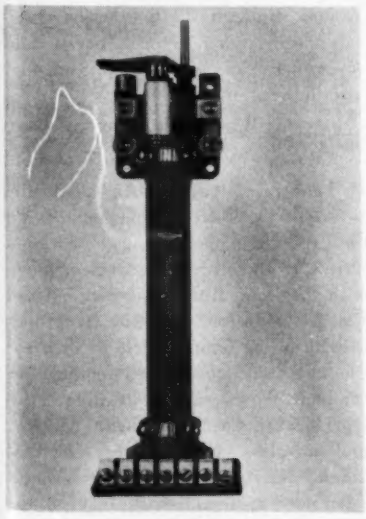


Fig. 1

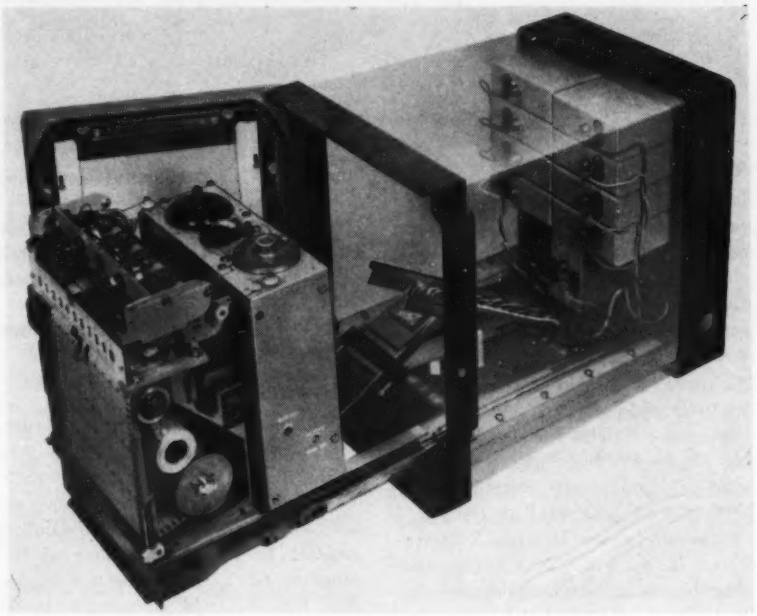


Fig. 2

SPECIAL FEATURES

There are several advantages to the new potentiometer, according to Brown Instruments, which should be of special interest to industrial users in general, and glass men in particular.

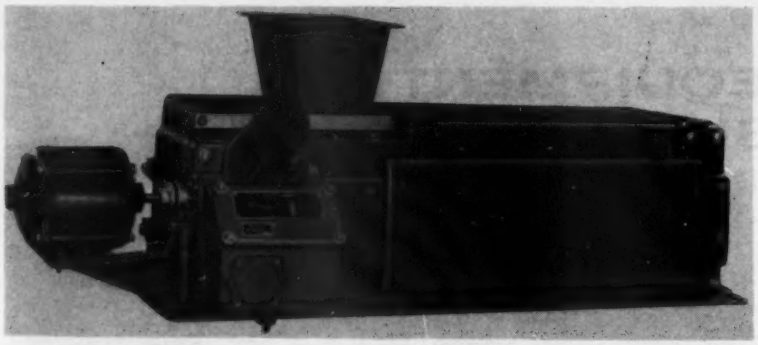
Modular construction. The new potentiometer is designed so that the display modules of each of the three models can be interchanged during an actual manufacturing process. These include the strip chart recorder which can be used for up to 31 days of continuous recording; the circular chart recorder for a 24-hour chart record; and the circular scale indicator for a continuous reading, but not a record.

Fig. 2 shows the strip chart model and its three sections: the display, drive, and case modules. The drive or center module contains the Stranducer, the range card and circuit board, amplifier, and constant current unit. The case module (right) houses the display and drive units, drawer-type chassis (into which the first two modules slide on a track). Also evident in the case module are the wiring drawbridge, control units, power supply for control system, and terminal board. The drawbridge can be unplugged by releasing two screws. In this way, the electrical contacts can be broken; it is not necessary to disconnect any wires when removing one display module and replacing it with another.

Transistor control unit. The plug-in design provides up to a maximum of eight set-points for auxiliary or zone control, any combination of which can be supplied originally or modified as required by the user in his plant.

Stray signal rejection. Loop stray signals, which have 60-cycle rms values five times greater than span, and voltage-to-ground strays of 300 volts dc or 150 volts ac will not impair the accuracy of the instrument.

Minneapolis-Honeywell Regulator Co., Wayne and Windrim Aves., Philadelphia 44, Pa.



Volumetric Feeder

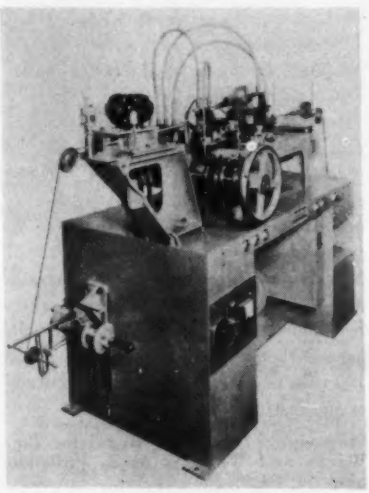
Measures all free-flowing powdered, granular, or lumpy solids by volume and has a maximum capacity of 3600 cubic feet per hour. Feed rate is adjustable by a dial setting over a 10:1 range, and accuracy is maintained within ±3% over any one-minute period. Belt speeds may be changed by means of a two-speed gear box to give a 100:1 range, and a variable speed drive, available on the 9″ model only, increases range to 1000:1 when combined with the two-speed gear box.

Either size of the Merchen Volumetric can be converted to a gravimetric feeder by adding weighing components. An optional off-feed switch stops the feeder or actuates an alarm when feed falls below a selected rate. Ask for 4-page catalog.

Wallace & Tiernan Inc., 25 Main St., Belleville, N.J.

Welding Machine

A new completely automatic two-piece lead wire welding machine which butt-welds a pre-determined length of lead wire to a slug of larger wire (such as Dumet) to produce a two-piece lead of high reliability. Machine can be set for high speed production, up to 10,000 leads per hour.



The weldments are used in glass body cases for encapsulating crystal diodes, and many other electronic and electrical applications.

Kahle Engineering Company, 3000 Hudson Avenue, Union City, N.J.

Recorder-Controller

A single-case time-program recorder-controller which provides a 50 per cent reduction in panel space requirements. The recorder chart and program cam are independently driven, making it possible to record repetitions of the program on a single chart. Program time may be from 30 minutes to 30 days. Various models of the instrument measure and control temperature, pressure (including absolute pressure), flow (mercury manometer or bellows-differential meter), liquid level, and humidity.

The Bristol Company, Waterbury 20, Conn.

Differential Pressure Switch

Suitable for applications such as liquid level controls, dust collection systems and air filters. Switch is designed for extremely accurate and reliable control in pressure ranges too low for conventional units. Repetitive accuracy is said to be within one per cent—with virtually no error owing to drift or hysteresis. Ask for Bulletin No. E-30.

F. W. Dwyer Mfg. Co., Dept. GI-4, P. O. Box 373, Michigan City, Ind.

High-Alumina Refractory

Said to have an unprecedented combination of improved physical properties and hot strength characteristics. Great increase in densification has lowered the porosity of refractories by as much as 40 per cent, according to the company, and has diminished the access of furnace fumes and slag.

In addition to showing no subsidence in the 3000°F hot load tests, the refractory (known as Korundal XD) shows no spalling loss in the 3000°F panel spalling test.

Harbison-Walker Refractories Co., 307 Fifth Ave., Pittsburgh 22, Pa.

Air Vibrator

New heavy-duty air vibrators for unloading covered railroad hopper cars are being used successfully on bulk trailers carrying potash, cement, and similar materials. They are said by the manufacturer to cut unloading time, eleminate "clean-out" of cars after emptying, and to free personnel for other works.

The 4″ piston size is 17½″ long, weight 115 lbs., and consumes 29 c.f.m. at a recommended air pressure of 40-6 p.s.i.

National Air Vibrator Co., 435 Literar Ave., Cleveland 18, O.

CATALOGUES RECEIVED

Wire cloth; metal-mesh belts (6 pages each). Bulletin #115 illustrates various types and grades of industrial wire cloth, along with listing of trade definitions. Bulletin #116 describes typical specifications of metal-mesh conveyor belts and shows several actual installations.

Cambridge Wire Cloth Company, Cambridge, Md.

Pyrometer (4 pages). An automatic, two-color pyrometer which includes an optical system permitting observation during temperature measurement along with freedom from emissivity effects. Can be used for indicating, recording or controlling temperatures in such applications as combustion control of luminous flames; crystal growing; electric furnace heating element control; molten glass temperatures; melting point determinations; and general laboratory testing.

Shaw Instrument Corp., Latrobe, Pa.

INVENTIONS AND INVENTORS

Feeding and Forming

Lamp Manufacture. Patent No. 2,946, 641. Filed August 23, 1957. Issued July 26, 1960. Three sheets of drawings; none reproduced. Assigned to Corning Glass Works, by William R. Wisner.

Various types of incandescent lamps are made in vast quantities. For this reason any change in a lamp structure or the method of its manufacture that effects even a minor saving in its per unit cost is greatly to be desired.

A lamp envelope with a moil-free neck is employed with a mount arranged in the envelope embodying an evacuating tube provided with a bulbous portion about which the free end of the neck is sealed.

Two opposite sides of the neck have apertures pierced therethrough through which the lead-in wires are threaded and sealed. The region of the neck wall surrounding the bulbous portion of the mount, at a level below the exit of the lead-in wires, is then sealed thereto and about the lower adjacent region of the mount. The moil portion of the lamp neck is then tipped off with the lower end of the mount following evacuation of the lamp.

There was 1 claim and the following references cited in this patent.

United States Patents

317,171, Muller, May 5, 1885; 709,996, McBerty et al., Sept. 30, 1902; 2,327,622, Craig, Aug. 24, 1943; 2,359,483, Kuebler, Oct. 3, 1944; 2,361,469, Flaws, Oct. 31, 1944; 2,685,762, Mullan, Aug. 10, 1954; 2,791,480, Larson, May 7, 1957.

Glass Compositions

Ion Exchange Glass and Use. Patent No. 2,943,059. Filed June 3, 1955. Issued June 28, 1960. No drawings. Assigned to Minnesota Mining and Manufacturing Company, by Warren R. Beck and George C. Hann.

This invention relates to new porous glass articles of manufacture possessing improved properties and comprising a residual vitrified glass structure of novel composition.

Articles of this invention possess an extraordinarily high capacity to remove ions from solutions. A particularly unusual use for the articles is the removal of radioactive ions, e.g., cesium, strontium, etc., from low pH solutions held at high temperatures on the order of approximately 250°C under several thousand pounds of pressure.

Broadly, the residual glass structure of the articles contains at least 90 mol per cent of a combination of inorganic constituents meeting the compositional requirement, as determined by analysis, set forth in Table I, wherein approximate amounts are specified in mol per cent.

The most preferred structures of the invention are those in the form of small glass beads having a diameter smaller than or below approximately 2 mm.

Table I

TiO_2	0-40
ZrO_2	0-35
HfO_2	0-35
$TiO_2 + ZrO_2 + HfO_2$	0-40
SiO_2	0-10
$AlO_{1.5}$	0-25
$BO_{1.5}$	20-70
$PO_{2.5}$	20-70
$PO_{2.5} + BO_{1.5}$	0-15
Fluxes	0-25
$BO_{1.5}$ + fluxes	

There were 12 claims and the following references cited in this patent.

United States Patents

1,749,823, Long, Mar. 11, 1930; 2,042,425, Kaufmann et al., May 26, 1936; 2,213,530, Montere, Sept. 3, 1940; 2,245,783, Hyde, June 17, 1941; 2,283,172, Bates, May 19, 1942; 2,477,649, Pincus, Aug. 2, 1949; 2,577,627, Pincus, Dec. 4, 1951; 2,578,325, Sun et al., Dec. 11, 1951; 2,587,916, Squier, Mar. 4, 1952; 2,691,599, Blau, Oct. 12, 1954.

Miscellaneous

Banded Hollow Glass Structural Unit. Patent No. 2,941,393. Filed December 7, 1956. Issued June 21, 1960. One drawing; not reproduced. Assigned to Owens-Illinois Glass Company, by Murray McDavitt and Harvard B. Vincent.

This invention relates to hollow glass structural units such as building blocks or domes, which are currently used in or contemplated for use in constructing walls, skylights, partitions, and/or other parts of buildings.

The block or dome has an impervious plastic band surrounding its side surfaces, which band is contoured to durably restrain the glass block or dome in weather-tight relationship throughout an extensive range of atmospheric conditions.

Still another object of this invention is to provide a method of forming an integrally-bonded, laminated plastic band surrounding the lateral side surfaces of a hollow glass dome-like structure to constitute an attachment annulus therearound for its detachable mounting in an extremely durable and weatherproof manner in a building structure.

There were 3 claims and the following references cited in this patent.

United States Patents

2,297,309, Limbert, Sept. 29, 1942; 2,318,362, Boeglen et al., May 4, 1943; 2,333,723, Jordan, Nov. 9, 1943; 2,397,242, Chubb et al., Mar. 26, 1946; 2,685,107, Schultz, Aug. 3, 1954; 2,703,486, Ford, Mar. 8, 1955; 2,714,816, Pennell, Aug. 9, 1955; 2,754,237, Brooks, July 10, 1956; 2,776,910, Erickson et al., Jan. 8, 1957.

Foreign Patents

489,803, Canada, Jan. 20, 1953.

CURRENT STATISTICAL POSITION OF GLASS

Employment in the glass industry during October, 1960, was as follows: *Flat Glass:* a preliminary figure of 26,200 for October, 1960, indicates an increase of 0.3 per cent over the adjusted figure of 26,100 for September, 1960. *Glass and Glassware, Pressed and Blown:* a decrease of 3.1 per cent is shown by the preliminary figure of 89,600 reported for October, 1960, when compared with the adjusted figure of 92,400 reported for September, 1960. *Glass Products Made of Purchased Glass:* the preliminary figure of 14,300 given for October, 1960, is 2.1 per cent over the adjusted figure of 14,000 reported for September, 1960.

Payrolls in the glass industry during October, 1960, were as follows: *Flat Glass:* an increase of 4.9 per cent is shown in the preliminary $15,018,169.33 given for October, 1960, when compared with September's $14,310,573.10. *Glass and Glassware, Pressed and Blown:* a decrease of 1.8 per cent is shown in the preliminary $35,849,586.11 given for October, 1960, when compared with the previous month's adjusted $36,533,689.50. *Glass Products Made of Purchased Glass:* a preliminary figure of $4,899,019.79 was reported for October, 1960. This is an increase of 3.1 per cent when compared with the adjusted figure of $4,752,261.08 for September, 1960.

Glass Container Production based on figures released by the Bureau of the Census, Industry Division, was 11,415,000 gross during November, 1960. This is a decrease of 18.3 per cent under the previous month's production figure, 13,968,000 gross. During November, 1959 glass container production was 12,246,000 gross, or 7.4 per cent over the November, 1960 figure. At the end of the first eleven months of 1960, glass container manufacturers have produced a preliminary total of 148,745,000 gross. This is 4.2 per cent more than the 142,683,000 gross produced during the same period in 1959.

Glass Container Shipments during November, 1960, came to 11,706,000 gross, a decrease of 9.9 per cent under October, 1960, which totaled 12,998,000 gross. Shipments during November, 1959, amounted to 9,589,000 gross or 18.1 per cent under November, 1960. At the end of the first eleven months of 1960, shipments have reached a preliminary total of 144,949,000 gross which is 2.1 per cent more than the 142,000,000 gross shipped during the same period of the previous year.

Stocks on hand at the end of November, 1960, came to 20,622,000 gross. This is 1.2 per cent under the 20,890,000 gross on hand at the end of October, 1960, and 23.2 per cent more than the 16,731,000 gross on hand at the end of November, 1959.

GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

Narrow Neck Containers

	November, 1960
Food	1,026,000
Medicinal and Health Supplies	1,359,000
Chemical, Household and Industrial	863,000
Toiletries and Cosmetics	797,000
Beverage, Returnable	592,000
Beverage, Non-returnable	132,000
Beer, Returnable	71,000
Been, Non-returnable	941,000
Liquor	957,000
Wine	405,000
Sub-total (Narrow)	7,143,000

Wide Mouth Containers

Food	*3,457,000
Medicinal and Health Supplies	388,000
Chemical, Household and Industrial	128,000
Toiletries and Cosmetics	271,000
Dairy Products	153,000
Sub-total (Wide)	*4,397,000
Total Domestic	11,540,000
Export Shipments	*166,000
TOTAL SHIPMENTS	*11,706,000

* This figure includes Fruit Jars, Jelly Glasses, and Packers' Tumblers.

GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

		Production November 1960	Stocks November 1960
Food, Medicinal and Health Supplies; Chemical, Household and Industrial; Toiletries and Cosmetics.	Narrow Neck	3,905,000	6,916,000
	Wide Mouth	*4,170,000	*6,729,000
Beverage, Returnable		598,000	2,387,000
Beverage, Non-returnable		130,000	343,000
Beer, Returnable		105,000	505,000
Beer, Non-returnable		962,000	1,119,000
Liquor		957,000	1,574,000
Wine		447,000	753,000
Dairy Products		141,000	293,000
TOTAL		*11,415,000	*20,622,000

* This figure includes Fruit Jars, Jelly Glasses, and Packers' Tumblers.

GLASS IN THE WORLD OF TOMORROW

(*Continued from page* 75)

We can expect to see airplanes with the window area as one continuous strip of glass for better visibility—this being possible because the glass will be structural as well.

In summation, I quote from our Pittsburgh Plate Glass Company President, David G. Hill:

"We are on the threshold of one of the greatest eras of change that the world has ever encountered. I am confident, however, that glass will be a major factor in space-age living.

Buildings with interior as well as exterior walls of glass, many of them with a cellulated or fiber glass insulating core, will be the pattern. Window areas will regulate their own light transmission as the sun brightens or diminishes.

"These windows will be of several varieties. Some will have fixed-response characteristics. Others will be changed by the occupant to provide desired characteristics. By the flick of a switch, windows will be made opaque.

"Glass panels that control the light transmission properties will be used as separating walls between rooms as well as in window areas.

"Not only will both natural and artificial light be controlled but the same glass will be energized to cool or heat a room without drafts. Air will pass through micro-openings. The porosity of these glass materials will be changeable. This will permit the control of the flow of cool or warm air to portions of the same room if desired.

"In homes of the 1960s and '70s, fiber glass will play an increasingly big role. Uses will include insect screening, insulation, laminated in gutters and downspouts, furniture, ceiling and flooring materials. Fiber glass fabrics in draperies and numerous other textiles will be in general use.

"Variable transmission glass, electroluminescent glass; electrical conducting glass, microporous glass with variable resistance to air flow; vacuum insulation blankets, fibers, foams and foamed fibers; solar energy collectors; curved, figured and colored glass parts; malleable glasses of steel-like strength—all of these, in combination with other new properties in products not yet foreseen, will provide the people of the coming decades a greater variety of new possibilities and combinations of glass properties than have been created in the entire last century."

THE GLASS INDUSTRY—1960

(*Continued from page* 73)

Today scientists are delving into the strange things that happen to glass in cooling which give it the characteristics of both a liquid and a solid. They are trying

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to find out what holds glass together. It is known that the surface strength inside a glass container is greater than outside; that something happens when molten glass comes in contact with the mold. Chemists and physicists are studying the rearrangement of molecular structure that takes place in glass blowing, and they are analyzing the materials used in the molds to deduce some of the unknowns that could make glass stronger and more flexible.

Beyond blowing techniques, the factor of greatest importance in reducing weight is the shape of a container. The most perfect shape for blowing equitable glass distribution is a sphere. As the shape deviates from a globe to oblong or square, surface area increases and the glass does not distribute in even thickness throughout the mold, leaving vulnerable contact points.

(To be concluded next month)

FIBER GLASS IN 1960

(Continued from page 88)

of other materials. They must also resist erosion resulting from impact with rain, hail, and snow, as well as atmospheric dust.

On the same airplane, there are miles of electrical wire insulated with fiber glass. The wires can be much smaller in diameter, with valuable space and weight saving, and they can withstand higher temperatures than are possible with other insulating materials.

Glass Reinforcement in Boats

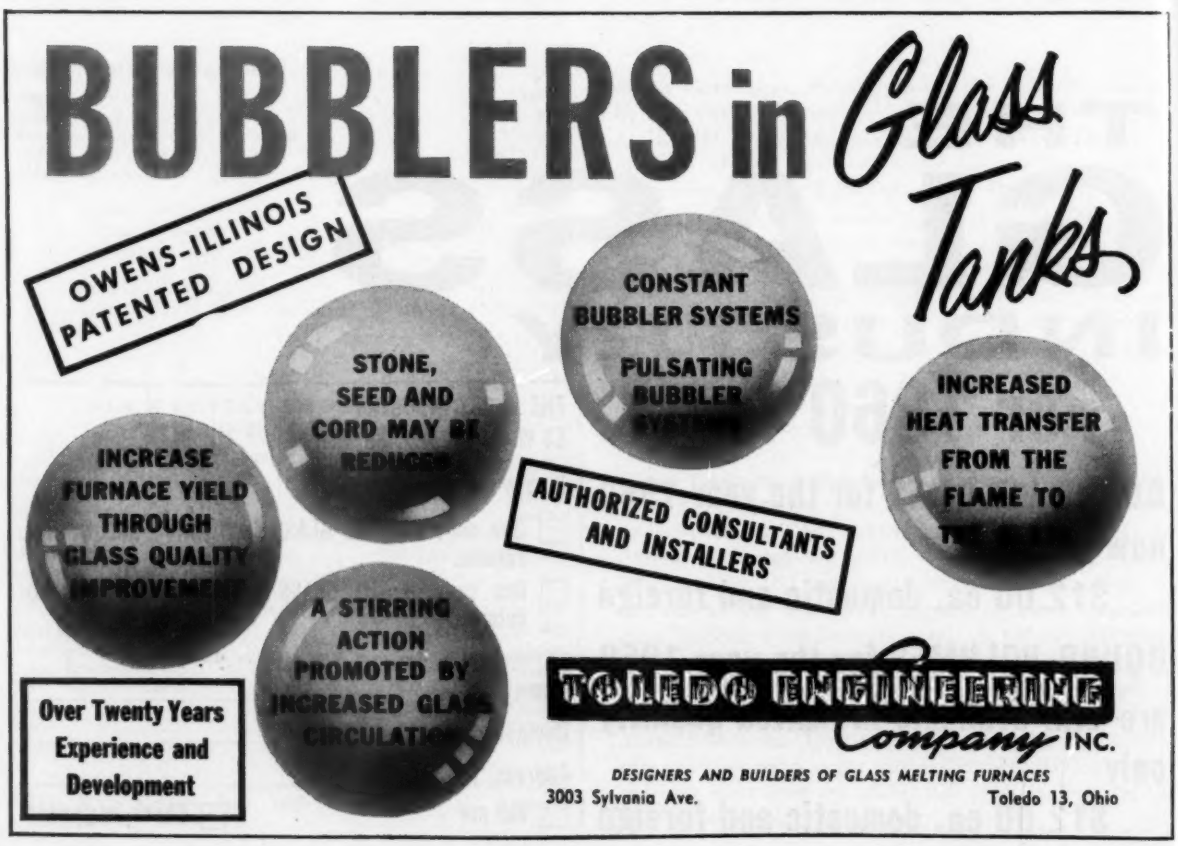
The largest single use of glass reinforced plastic today is in the pleasure boat field. Mass production of glass reinforced boats started in the early 1950's. The acceptance of the material has grown at an astounding rate so that in 1959 it was estimated that 40 per cent of all small pleasure boats produced were of glass-plastic construction.

In 1958 approximately 85,000 molded-plastic boats were turned out by an estimated 300 builders. In 1959 unit production made a spectacular leap to approximately 130,000 units.

The two big 1960 national boat shows in New York and Chicago revealed a continuation of the trend to glass fibers in boats. In New York more than 35 per cent of the boats were reinforced plastic, while in Chicago over 50 per cent of the boats were reinforced plastic *

The rapid growth of glass reinforcement in this field is undoubtedly due to its exceptional suitability and unique combination of properties for the application. Glass-plastic boats will not rot, rust, corrode, or generally give way to those infirmities which plague all wooden or metal boats. Their hulls and decks are seamless and leak proof. The material does not swell or shrink, nor is it adversely affected by atmospheric temperature extremes.

*See "1961 Motor Boat Show," page 91 in this issue.


BUBBLERS in Glass Tanks
OWENS-ILLINOIS PATENTED DESIGN
CONSTANT BUBBLER SYSTEMS
PULSATING BUBBLER
STONE, SEED AND CORD MAY BE REDUCED
INCREASED HEAT TRANSFER FROM THE FLAME TO
INCREASE FURNACE YIELD THROUGH GLASS QUALITY IMPROVEMENT
AUTHORIZED CONSULTANTS AND INSTALLERS
A STIRRING ACTION PROMOTED BY INCREASED GLASS CIRCULATION
Over Twenty Years Experience and Development
TOLEDO ENGINEERING Company INC.
DESIGNERS AND BUILDERS OF GLASS MELTING FURNACES
3003 Sylvania Ave.
Toledo 13, Ohio

Aside from the excellent properties which are inherent in the material, glass-plastics offer great possibilities for the designer with resultant benefits to the consumer. The combined glass and resin materials in their uncured state are limp and characterless and can be formed into unlimited shapes and contours which are impossible or impractical in wood or metal. In boat construction, this feature is never more dramatically displayed than in the case of the 40-foot glass-reinforced pleasure yachts which are molded in two or three monolithic sections, bonded permanently together.

The boat building boom is continuing without any foreseeable saturation point. Yearly production in the outboard category will conservatively increase by 50 per cent before 1965—to a total production of about 600,000 units. This continued market expansion forms the brightest future for glass-plastic boat builders who each year take a larger section of the total sales. Those in the molded glass boat industry see no reason why they cannot take over a larger percentage of the market in the next few years. Improved metal and wood construction will obviously develop, and probably new, untried synthetics will serve some specialized demands, but no material is evident today which has the versatility, adaptability, and range of advantages for small boat construction which glass reinforcements offer.

Fiber Glass AF (All Fiber) Insulation

New fiber glass AF (all fiber) insulation applications include a break-through in the appliance industry's long quest for effective insulation in thin wall refrigerators to provide more refrigerator and freezer space without increased outside dimensions. During the year 3 major manufacturers introduced thin-wall insulation embodying the AF product, and applications by others are being developed.

Fiber Glass Flake

Fiber glass flake (Owens-Corning Fiberglas), is being field tested as a spray-on protective coating for steel, concrete, and wood. This product has good adhesion to steel and can meet most problems of acid attack, moisture penetration, and abrasion encountered in tank linings, metal and concrete pipe linings, and similar applications.

A 200 sq. ft. test patch of fiber glass flake was applied last winter to the corroded steel hull of the *Joseph Conrad*, a square rigged sailing ship. The vessel was left in tidewater from October until May, then drydocked and inspected. The protective coating was found to be securely in place and behind it the hull's iron plates were "bone dry." (See THE GLASS INDUSTRY, page 644, November, 1960)

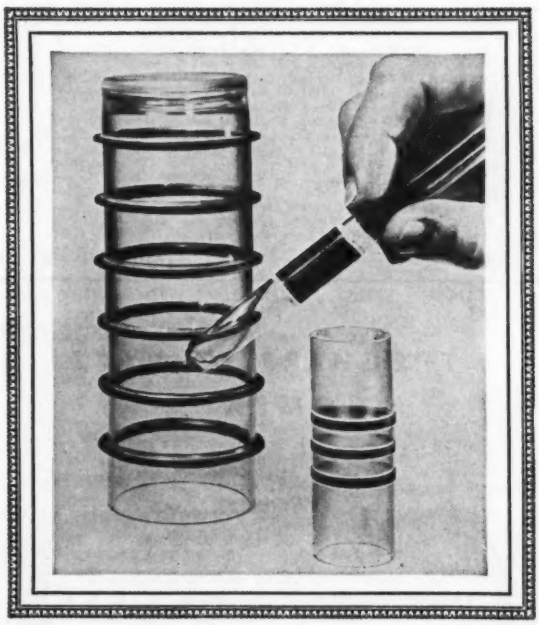
Another use evidencing continued progress is in the form of polarizing light panels.

How well do you know your glass?

THIS PHOTO SHOWS:

- ☐ 1. Laboratory graduates
- ☐ 2. College graduates
- ☐ 3. Glass-to-molybdenum seals
- ☐ 4. Battery jars

A new high-temperature glass-ceramic frit, used principally in stack-mount-type tube construction, seals aluminosilicate glasses to themselves, molybdenum, or tungsten. Shown here are glass-to-molybdenum seals. In 70 years as a supplier of Soda Ash to the glass industry, Wyandotte has witnessed many marvels made possible by glass. Today, as in the past, Wyandotte is a working partner supplying technical assistance and raw-material chemicals to those great companies marking milestones in glass progress.



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